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OUR DUTY

BY RUFUS T. STROHM

PLUNGED from the calm of a peaceful neutrality
Into the heart of the welter and strife,
Brought face to face with the war's stern reality,
New issues rise in our national life.
Gone is the hour for vain shilly-shallying,
No one must falter and no one must lag;
We must solve problems without any dallying;
That is the least we can do for the flag.

Some of us, driven by motives ulterior,
Saved in our plants when we felt so inclined,
Afterward posing as beings superior,
Knowing far more than the rest of our kind
That which we did to display our ability,
Something of which we could chuckle and brag,
Now is a matter of sense and utility,
Now it's a duty we owe to the flag.

Many's the time that we played to the gallery,
Trying to capture the eye of the boss,
Hoping he'd give us an increase of salary
Each time we managed to stop up a loss.
Then came the war with its mandates imperious,
Lending new zest to that primitive gag;
Now all our efforts at saving are serious;
That is a duty we owe to the flag.

Letting the habits of indolence seize on us,
Wasting our energies, efforts or time,
Borders almost on the edge of the treasonous,
Closely approaches a national crime.
But, if we rid us of prodigal squandering,
Free us from all that can hinder or drag,
Meet events sanely, without any maundering,
We can bring victory home to the flag.

A. Weil

Chain of Rocks Remodeled Boiler Plant—III

By H. F. GAUSS

Placing superheaters in remodeled water-tube boilers. Results from various arrangements of baffles to secure the guaranteed boiler efficiency and superheat.

AS ORIGINALLY installed the National boilers in the Chain of Rocks plant were vertically baffled. After 10 or 12 years of service these baffles had become leaky and were replaced with horizontal baffles, as shown in Fig. 1. The tubes were 4 in. diameter, spaced alternately on 6- and 7½-in. vertical and 7-in. horizontal centers. Fig. 2 shows diagrammatically the setting of the O'Brien boilers before they were reconstructed.

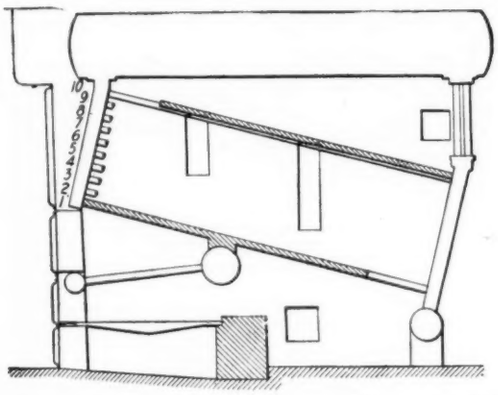

FIG. 1. NATIONAL BOILER HORIZONTALLY BAFFLED

When the contract for the chain-grate stokers was let, it was with the understanding that the settings were to be as shown in Figs. 3 and 4, with the exception of the superheaters. Also in Fig. 4 the lower baffle was over the first, instead of the second, row of tubes.

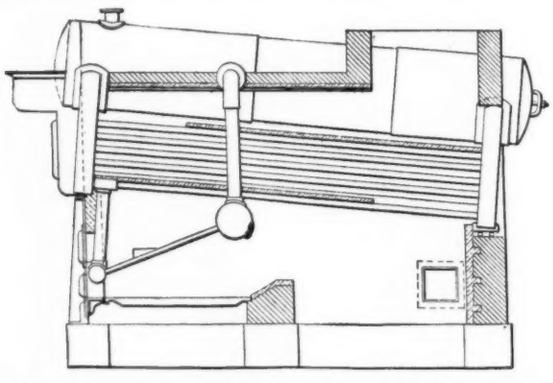

FIG. 2. O'BRIEN BOILER BEFORE RECONSTRUCTION

The stoker contractor later requested permission to raise the lower baffle above the second row of tubes in the National boilers on the ground that a lower final flue temperature would thus be obtained with a resultant gain in efficiency. The O'Brien boilers then remained as shown in Fig. 3, and in the National setting the lower baffle was raised as requested.

Shortly after the stoker contract was let, it was decided to install superheaters in each setting and a contract was let for the installations shown in Figs. 3 and 4. This was an advantage to the stoker contractor as it gave additional heat-absorbing surface and would reduce the final gas temperatures.

After the stoker and superheater installations had been completed and preliminary tests conducted, it was found that the over-all efficiency of 68 per cent., which

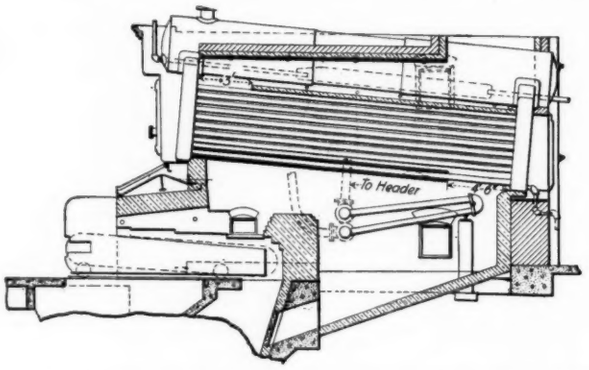

FIG. 3. SETTING OF O'BRIEN BOILER AS PLANNED FOR STOKER AND SUPERHEATER

the stoker contractor had guaranteed, was not to be obtained, and the superheat was also considerably below that guaranteed; namely, 125 deg. The furnace efficiency considered separate from the boiler was as good as could be expected. The CO_2 was high, the ash contained but a small amount of combustible, and the combustion-chamber temperatures were high.

Column I in the accompanying table gives the results of a preliminary test on a National boiler, with the setting as shown in Fig. 4, and Column II, the results of a similar test on one of the O'Brien boilers. In each case an excessive flue temperature obtained, showing plainly that the boilers were not absorbing the heat generated. The fault was not in the boilers themselves inasmuch as they had all been thoroughly turbined and overhauled.

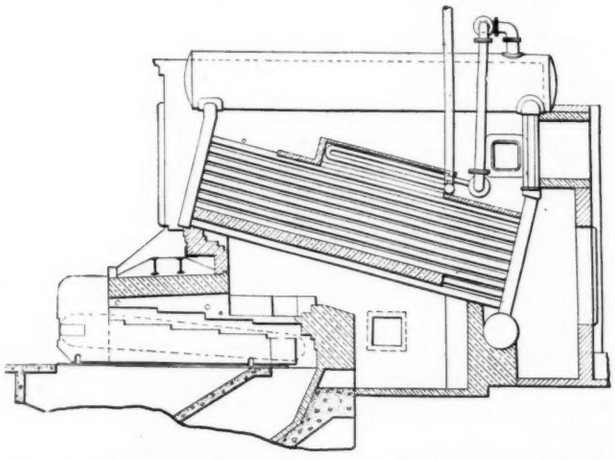

FIG. 4. NEW SETTING DESIGNED FOR NATIONAL BOILER

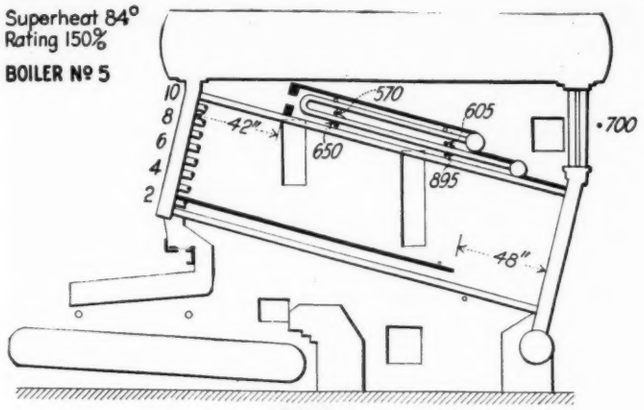

FIG. 5

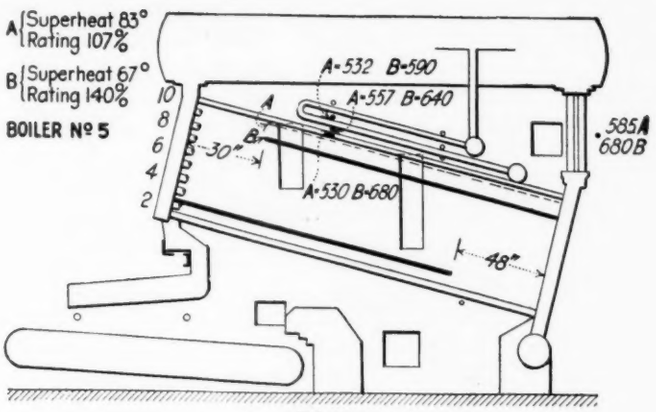

FIG. 6

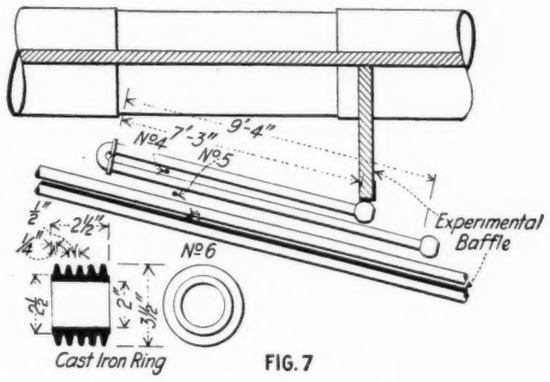

FIG. 7

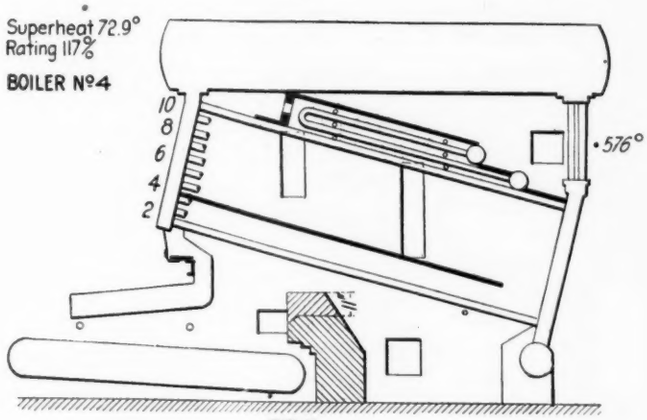

FIG. 8

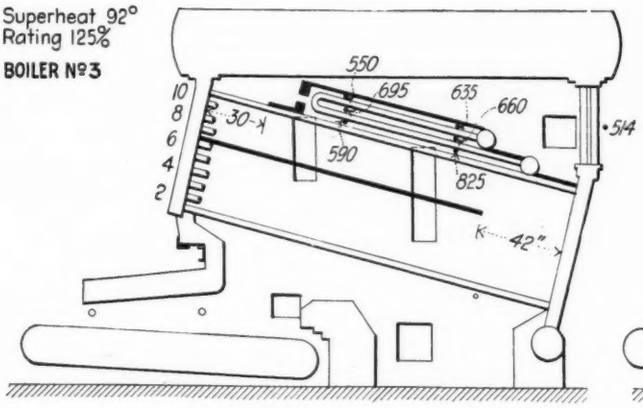

FIG. 9

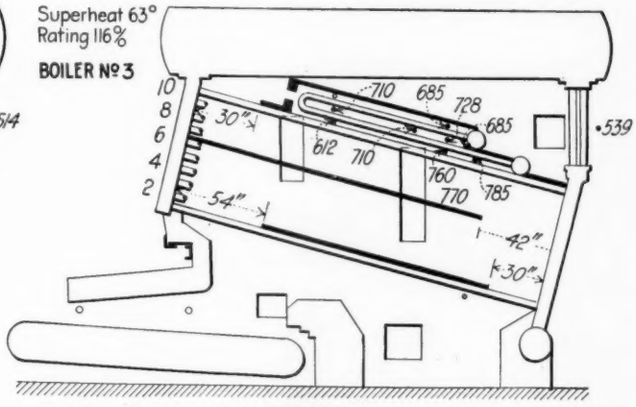

FIG. 10

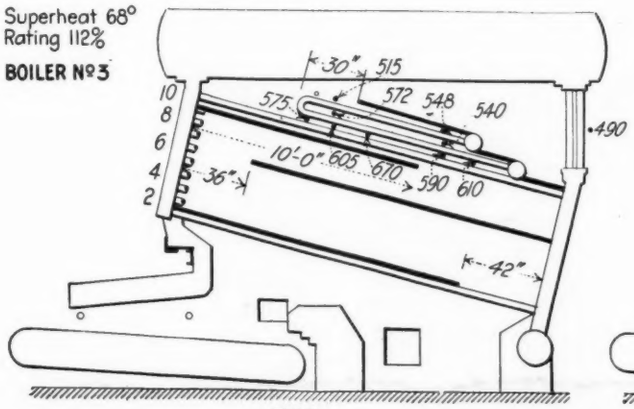

FIG. 11

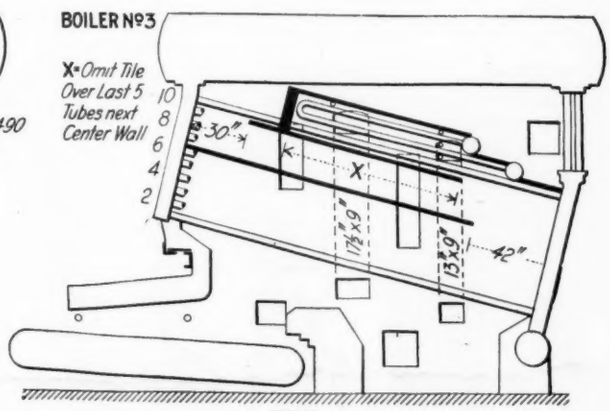

FIG. 12

FIGS. 5 TO 12. ARRANGEMENTS AND LOCATIONS OF BAFFLES TO INCREASE SUPERHEAT

Based on Azbe's method of determining the weight of flue gases resulting per pound of coal fired and assuming 3 per cent. available hydrogen (see *Power* Apr. 24, 1917, p. 554), there were probably 16.6 lb. of flue gases passing from the National setting per hour per pound of coal. The temperature of the gases was 205 deg. in excess of 500 deg., the latter temperature being the maximum that should be reasonably allowed, in view of the fact that no economizers were provided. The prospects looked bad for the superheaters on the National boilers, since they were located comparatively near to the breeching end of the boilers, and to lower the flue-gas temperatures materially would lower the superheater-chamber temperatures and also the superheat.

Too High Temperature

Assuming that the specific heat of the flue gases is the same as for air, 0.24, the heat given up by 16.6 lb. of flue gases per hour per degree drop in temperature would be 3.98 B.t.u. On the other hand, assuming that the mean specific heat of steam between 80 and 125 deg. of superheat is 0.54, then 6.05 lb. of steam (the evaporation per pound of coal) will absorb 3.27 B.t.u. per degree rise in temperature. It follows therefore that to raise the superheat from 80, that obtained in the test, to 125 deg., that guaranteed, would lower the flue-gas temperature 37 deg., giving a final temperature at the setting outlet of 668 deg.—still entirely too high. Evidently, the high flue-gas temperature was not entirely due to the failure of the superheaters to give the desired steam temperature and any move to produce a higher superheater-chamber temperature could only increase the flue temperature.

It was thought, however, that if a greater volume of gas at the temperature obtained in the superheater chamber could be induced to pass through it, the required superheat might be obtained even though the flue temperature remained high. To determine whether this theory was correct, the superheater chamber was opened up in front, as shown in Fig. 5. Observations showed that the superheat was raised some 4 deg., but not sufficient to meet the original guarantees, and the flue temperatures remained abnormally high.

Gases Through Superheater

To compel all the gases to pass through the superheater chamber and determine beyond doubt whether this would produce the required superheat, an arrangement of baffling shown diagrammatically in Fig. 6 and in detail in Fig. 7 was constructed and tried out. The top horizontal baffle was first placed on the ninth row of tubes, with the results indicated under *A* in the figure; after which it was lowered to the eighth row, with the results indicated under *B*. Baffle *A* was a step in the right direction as far as flue temperatures were concerned, but the superheat was lowered owing to the fact that the flue-gas temperature in the superheater chamber was lowered. The conclusions drawn from the results of these experiments were:

1. There was not sufficient superheater surface to enable enough heat to be absorbed, at the temperatures available, to produce the required superheat.

2. No material difference in the superheat was made by causing a greater volume of gas at the same temperature to pass through the superheater chamber.

3. A decrease in gas temperature and an increase in gas volume passing through the superheater chamber resulted in a lower superheat.

The scheme of baffling shown in Fig. 8 was next tried The lower horizontal baffle was raised to the top of the third row and the bridge-wall was raised as indicated, the idea being to deflect the gases up into the tubes in an effort to absorb more heat in the combustion chamber. The 6-ft. stoker arch was depended upon to insure proper combustion, and it was thought that the high bridge-wall by reflecting the intense heat would also improve combustion.

Column III of the table gives the results of a test conducted on National boiler No. 4 after making the alteration shown in Fig. 8. A decided lowering of the flue-gas temperatures was secured, and a consequent gain in efficiency resulted. This arrangement would probably have been successful had it been possible to maintain it for a reasonable period of time. As it was, however, the accumulation of fused fly ash on the top of the bridge-wall and between the tubes was so rapid that after a run of two weeks the boiler had to be shut down and the setting thoroughly cleaned. In addition to this, the superheat remained low, and the flue temperatures, though greatly reduced, were still high.

Lowered Bridge-Wall

The next move was to lower the bridge-wall to its original height and raise the lower baffle to the top of the sixth row as shown in Fig. 9. To place the baffle as shown, two cast-iron doors were located in the side wall through which the baffle tile could be passed, and by means of a special tool it was possible to get them into their proper places. Remarkably low flue temperatures were obtained, and while a complete boiler test was not conducted, readings of the steam-flow meter and automatic coal scales indicated an efficiency above 70 per cent.

The superheat still remained low, and in an effort to get hotter gases up into the superheater chamber a baffle on top of the lower row of tubes was located as shown in Fig. 10. The theory was that the gases leaving the furnace would divide, some passing up through the front opening and the remainder passing over the bridge-wall and up through the rear opening. It was thought that those passing to the rear would be crowded up into the superheater chamber and, since they did not wipe as much heating surface as those passing up through the front, would remain at a higher temperature, thus increasing the temperature in the superheater chamber. It was found that until the boiler was well up to rating, all the gases passed up through the front opening and when the load was increased to 115 per cent. of rating, the gases divided and part passed to the rear of the setting. The temperature in the superheater chamber was increased, but not sufficiently to produce the required superheat, and the flue-gas temperatures were also increased.

The scheme of baffling shown in Fig. 11 was next experimented with, and the results secured were as indicated on the sketch. With this system of baffling, all the flue gases were compelled to pass through the superheater chamber. However, their temperature was considerably lowered by the time they reached the superheater. The superheat remained low, and a low flue

temperature obtained. The steam-flow meter and automatic scales indicated an efficiency of 70 per cent.

This was the last system of baffling tried. It will probably not be possible to better the efficiency without economizers, and it seems impossible to obtain the required superheat with the superheaters in the location shown. There remain but two means of securing the superheat, and the Water Division has resorted to both successfully on other occasions. One is to provide flues in the outside walls leading from the combustion chamber up into the superheater chamber, with tile dampers to control the amount of hot gases thus bypassed. The construction of the superheater chamber would necessarily be altered by providing a tile baffle between it and the top row of tubes extending from the outside wall two-thirds of the way across the setting, as shown in Fig. 12. The bypassed gases from the combustion chamber enter the superheater chamber at a comparatively high temperature, flow across it and pass down among the boiler tubes, thence out through the last pass and into the breeching with the remaining products of combustion. There is no doubt that the required superheat could be secured by this means, and by compelling the gases leaving the superheater chamber to pass down among the boiler tubes, the final flue temperature would not be increased.

The other method of securing the superheat would be to place the superheaters in the combustion chamber. This is the most positive and desirable means, and will probably be resorted to in the present case.

PRELIMINARY TESTS ON CHAIN OF ROCKS BOILERS

No. of test	I	II	III
Duration, hours	5½	2½	5½
Steam pressure, lb. gage	126.1	131.1	127.7
Steam pressure, deg. F	433.5	575	427.3
Temperature corresponding to pressure	353.5	357	354.4
Superheat, deg. F	80	218	72.9
Temperature feed water, deg. F	174.9	150	174.2
Weight feed water, lb	77,408	20,210	72,090
Weight coal, lb	12,797	4,443	12,186
Average CO_2, per cent	9.5	10	10.3
Actual evaporation, lb	6.05	4.56	5.91
Factor of evaporation	1.13	1.225	1.125
Equivalent evaporation, lb	6.86	5.7	6.65
Efficiency, per cent	63.4	55.5	70.1
Horsepower	463	287	427
Rating, per cent	127	115	117
Draft over fire, in	0.26	0.26	0.25
Draft in breeching, in	0.5	.....	.....
Temperature in breeching, deg. F	705	741	576
B.t.u. in coal	10,000	11,160	9,200

While the moderate superheat indicated in the foregoing figures and discussion can be readily obtained, there is not sufficient room in this location to permit enough superheater surface for producing high degrees of superheat. The superheater contractor coöperated with the Water Division in every way possible in making these experiments, and the information gained should be valuable to power-plant operators contemplating the installation of superheaters.

Hot-Water Heating Under Forced Circulation—III*

BY CHARLES D. ALLAN
Consulting Engineer for the Mechanical Equipment of Buildings, Chicago.

Relative resistance of fittings in lineal feet of straight pipe. Influence of gravity small in forced-circulation work. Types of circuit employed.

PRACTICAL designers in forced-circulation heating give little consideration to the resistance to flow of valves, fittings, etc. While the relative resistance of fittings of different size in terms of lineal feet of straight pipe of the same diameter can be determined with reasonable accuracy, the proper empirical coefficients cannot be so easily ascertained on account of the great divergence in design of different makes. The following has been compiled from such meager information as is obtainable and is presented rather as an analysis showing that, particularly in smaller sizes of pipe, neglect of this resistance in practical work is justifiable, rather than for the accuracy of the data.

Most treatises on hydraulics give the friction-head loss for fittings as a multiple of the velocity head ($V^2 \div 2g$), or as g is a constant, this is equivalent to saying that it varies as the square of the velocity of flow. It seems, however, much more logical to assume that this resistance is a multiple of V to the same power as in the case of straight pipe, or 1.875, and if the head necessary to balance it is called H_R, as distinctive from H_F, it may be expressed by the equation,

$$H_R = CV^{1.875} \qquad (9)$$

in which C is an empirical constant that varies with different fittings. Calling H_R in this formula equal to H_F in formula (1) of the second article of this series (Oct. 2 issue), to get the equivalent lengths of straight pipe, and expressing d in inches gives

$$L = \frac{Cd^{1.25}}{(0.00038)(12)^{1.25}} = Cd^{1.25} \qquad (10)$$

in which C is also a constant with different values for different fittings; or in other words, the equivalent length in feet of straight pipe varies directly as the diameter to the 1.25 power.

From this equation Table I has been compiled, the values of C given at the top of each column being those which will make the total H_R for each fitting substantially the same as given in the "Mechanics of Heating and Ventilating," by Konrad Meier, previously referred to. A noticeable feature of this table is that the larger the fitting the greater is the equivalent length of pipe of the same inside diameter which will offer the same resistance to the flow.

The effect of gravity, or the difference in weight between the water in the supply and return mains due to difference in temperature and density, which is the force that produces circulation in ordinary systems of house heating by hot water, is also a factor that should receive some consideration. In forced-circulation work.

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however, it is so small when compared with the head produced by the pump, that it is not considered, except that the piping is so arranged that the flow will be in the direction naturally induced by gravity and not contrary to it.

An analysis of the exact effect of gravity in assisting circulation will show that the neglect of this force except as a factor of safety is justified. Table II is figured on the basis of the density of water at different temperatures as given in Merriman's "Hydraulics," and shows how small the influence of gravity is in work of this character. For example, an ordinary factory building of, say, five stories, or 60 ft. total height, initial water temperature of 200 deg. and 20-deg. drop, would have a mean effective differential head due to gravity of $0.0075 \times 60 = 0.45$ ft., while the circulating pump would probably be designed to produce a differential head of at least 60 ft. if the installation was of fair size and involved a number of buildings. This in turn accounts for the exceedingly small pipe sizes in forced-circulation work as compared to systems in which gravity alone is depended upon to give circulation.

Figs. 1 to 4 show some simple diagrams which, if carefully studied, will greatly facilitate the intelligent application of the charts in the second article to practical work, as all systems of hot-water heating under

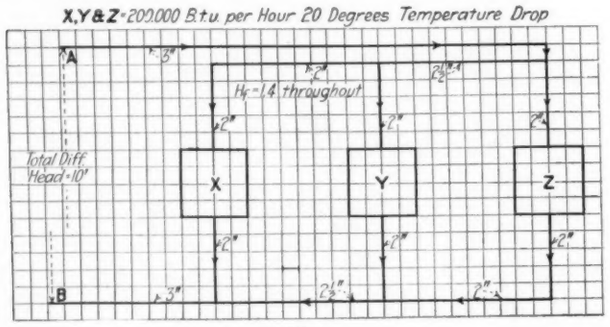


FIG. 1

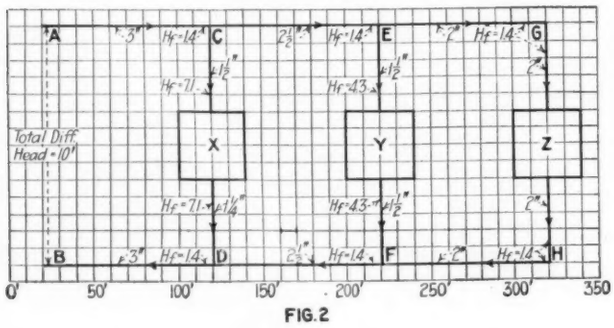


FIG. 2

FIGS. 1 AND 2. LAYOUT AND PIPE SIZES FOR VARIOUS CIRCUITS

Fig. 1—All circuits of same length. Fig. 2—Circuits of different lengths

forced circulation are based on the elementary principles they illustrate.

In Figs. 1, 2, 3 and 4, rectangles *X*, *Y* and *Z* are assumed to be heat-emitting surfaces which give off heat at the rate of 200,000 B.t.u. per hour each. The three units are connected by a system of piping through which water circulates under the different heads between *A* and *B* noted on the diagram in each case. Distances are indicated by squares the sides of which represent 10 ft., arrows show the direction of flow, and the sizes of commercial pipe that most nearly fill the condition are marked on each line.

In Fig. 1 all circuits are the same length (700 ft.) so that H_F is the same in all (1.4 ft. per 100 ft.). The pipe sizes indicated were obtained from the charts appearing in Article II. As previously stated H_F is the friction-head loss per 100 lin.ft. of pipe, in this case = 1.4, and is obtained by dividing the total differential head between *A*, the beginning of the circuit, and *B*, the ending of the circuit; namely, 10 ft. ÷ 7, the number of 100-ft. lengths. In the following, H_F

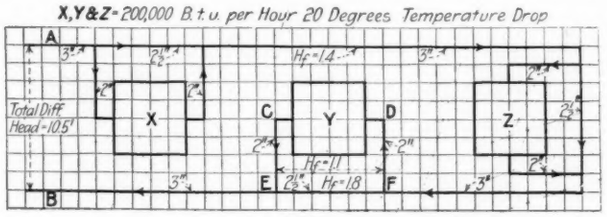


FIG. 3

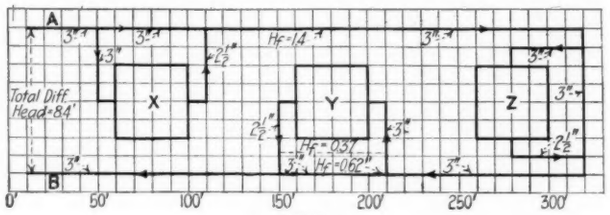


FIG. 4

FIGS. 3 AND 4. SHUNT SYSTEM PIPING SIZES

Fig. 3—Shunt circulation, theoretical sizes. Fig. 4—Shunt circulation as in practice

is likewise the friction-head loss per 100-ft. length of main expressed in feet height of water column.

In Fig. 2 each of the three possible circuits are of different length, in which case the key circuit from which to work is the long circuit *AGHB*. In this circuit it is assumed that H_F is uniform throughout, or 1.4, as in Fig. 1. It is evident that there is a larger head available to produce circulation between *E* and *F* than between *G* and *H* and a still larger difference of head between *C* and *D*. Hence H_F is proportionally larger in *CD* and *EF* than in *GH*, as indicated. The friction head in the three circuits will then substantially balance as follows:

Circuit AGHB: $7 \times 1.4 = 9.8$ *ft. total*

Circuit AEFB: $4 \times 1.4 = 5.6$

$1 \times 4.3 = 4.3$

9.9 *ft. total*

Circuit ACDB: $2 \times 1.4 = 2.8$

$1 \times 7.1 = 7.1$

9.9 *ft. total*

Fig. 3 shows what is known as "shunt circulation," which in fact is a modification of Fig. 2. In this figure the diagram is theoretically correct, but in practice that part of the main line inclosed by the shunt is made the same size as the main line itself. This naturally increases the size of the connections to give the same proportion of flow, and in this case the pipe diameters would be as indicated in Fig. 4.

These illustrations, Figs. 1 to 4, show in elemental form the three systems of water distribution that form

the component parts of every system of piping employed in this type of work. In individual buildings, that shown in Fig. 1 is used, all circuits being made substantially the same length, so that H_F is uniform throughout the building and calculation of pipe sizes is much simplified. In the case of factory work the extra length of pipe represented by the top 3-in. line in the diagram is left exposed and is figured as heating surface, so that the additional cost is negligible.

In an underground system connecting a group of buildings the system shown in Fig. 2 would be used. The connections are few in number compared to the interior work, making friction-head equalization in the various circuits comparatively easy. The cost of the

TABLE I. LINEAL FEET OF PIPE HAVING SAME FRICTION HEAD LOSS AS VALVES OR FITTINGS

Size In.	Extra Long Turn Ell C=0.82	Long Turn Tee or Ell Straight Ahead Through Run One Size C=1.1	Standard Ell or Tee Straight Ahead Through Reducing Two Sizes C=1.65	Angle Valve C=2.2	Standard Tee Through Outlet C=3.3	Globe Valve C=4.95	Radiator or Coil C=5.77
½	0.5	0.6	0.9	1.2	1.8	2.7	3.2
¾	0.7	0.9	1.3	1.7	2.6	3.9	4.6
1	0.9	1.2	1.8	2.3	3.5	5.3	6.2
1¼	1.2	1.6	2.5	3.3	4.9	7.4	8.6
1½	1.5	2.0	3.0	4.0	6.0	9.0	10.5
2	2.0	2.7	4.1	5.4	8.2	12.3	14.3
2½	2.6	3.4	5.1	6.8	10.2	15.3	17.9
3	3.4	4.5	6.7	8.9	13.4	20.1	23.5
3½	4.0	5.4	8.0	10.7	16.1	24.1	....
4	4.7	6.3	9.4	12.5	18.8	28.3	....
4½	5.4	7.2	10.8	14.4	21.6	32.5	....
5	6.2	8.3	12.5	16.6	24.9	37.4	....
6	7.9	10.5	15.7	20.9	31.4	47.1	....
7	9.4	12.6	18.9	25.1	37.7	56.5	....
8	11.2	15.0	22.4	29.9	44.9	67.3	....
9	12.7	17.0	25.5	34.0	51.0	76.4	....
10	15.0	20.0	30.0	40.0	60.0	90.0	....
12	18.6	24.8	37.2	49.5	74.3	111.5	....
14	20.8	27.8	41.7	55.6	83.4	125.0	....
15	22.8	30.4	45.6	60.9	91.3	136.9	....
16	24.8	33.1	49.7	66.2	99.4	149.0	....
18	29.0	38.6	58.0	77.3	115.9	173.9	....
20	33.2	44.3	66.5	88.6	133.0	199.4	....
22	37.6	50.2	75.2	100.3	150.4	225.7	....
24	42.1	56.1	84.2	112.2	168.3	252.5	....
26	46.7	62.3	93.5	124.6	186.9	280.3	....

Sizes over 12 in. are O.D.

TABLE II. EQUIVALENT HEADS IN FEET OF MEAN DENSITY PER ONE FOOT MEAN HEIGHT OF RADIATOR ABOVE BOILER

Initial Temp. Deg. F.	Temperature Drop, Degrees F. 20	25	30	35	40
210	0.0078	0.0098	0.0113	0.0133	0.0151
205	0.0076	0.0095	0.0111	0.0129	0.0146
200	0.0075	0.0091	0.0109	0.0126	0.0144
195	0.0073	0.0091	0.0107	0.0125	0.0142
190	0.0073	0.0089	0.0107	0.0123	0.0138
185	0.0069	0.0087	0.0104	0.0118	0.0135
180	0.0069	0.0085	0.0100	0.0116	0.0131

extra pipe line to equalize the length of circuits as in Fig. 1, which in this case could not be employed as heating surface, is avoided.

Shunt connections as shown in Figs. 3 and 4 may be used to advantage in interior work. Piping will be saved, but care should be taken not to string too many radiators on one line, as the end ones will become too cold.

Pipe connections from the boiler to the water column should be as short and as direct as possible, and in size not less than 1¼ in. No attachments, except a steam-gage, should be connected to the piping of a water column; and no connections for supplying steam or water should be allowed on the water-column pipes under any pretext. The slightest flow of water or steam in the pipes of a water column will render its indications of the water level unreliable.

Inquiries about flash boilers from airplane makers suggest that steam may yet be the motive power for large 'planes.

Corrosion in Refrigerating Plants

By M. A. Saller

Some of the most troublesome problems encountered in the refrigerating plant are those due to corrosion of the brine and other piping, coils, condenser tubes, etc. Air in the water, having oxygen as the active agent, causes considerable corrosion. Free acids may get into the boiler, and acidity of the boiler water may develop because of decomposition of mineral salts. Material in torsional stress is very susceptible to corrosion. As a general rule it can be said that most of this trouble from corrosion is due to impure or contaminated water supply, while the remainder can usually be traced to local conditions.

One of the main causes of corrosion can be traced to the presence of quantities of air in the piping or coils. This air, carrying oxygen as its active agent, naturally tends to increase corrosion, the oxidizing power of the oxygen gas gradually attacking the iron with which it comes in contact. This oxygen is brought into the pipe line through the entrained air contained in the water, the air and gas being driven out of the water when subjected to heat; also due to air leaks.

Must Keep Air Out of System

To prevent corrosion from this source, care should be taken to prevent leaks which permit the admission of air. The pumps and other parts of the system, involving stuffing-boxes or other connections highly susceptible to air leaks, should be gone over frequently to make sure that trouble is not being engendered from this source. It should also be made a special point to keep the piping system constantly filled with water or brine so that air pockets will not be formed. Frequently it will be noticed that corrosion is more rapid and violent in the upper parts of a piping system, or even an open tank, because of the tendency of the air to accumulate at the high points. Often air chambers are placed at elevated portions of the piping system where the air will be allowed to accumulate and then be blown off through a pet-cock or valve.

Corrosion in the boiler-feed lines, boilers and steam lines is often occasioned because of air introduced in the feed water, this air being liberated when the water is heated to a high temperature. Probably the most effective method of ridding feed water of air is the use of a good design of open-type heater, because in this apparatus the water is broken up into small particles and heated with steam, which naturally results in the driving off of the air which is liberated through the steam outlet or vent of the heater.

Acidity of Feedwater

Another frequent cause of corrosion, more especially in the boilers and feed lines, is acidity in the free state contained in the water or else acidity developed in the water by the dissociation of one or more of the mineral salts contained. Free acids, such as sulphuric acid, carbonic acid, etc., are usually found only in surface waters, in which they find their way owing to contamination, especially caused by the water discharge and residue from coal and other mines where the free sulphuric acid exists in combination with the other minerals. The contamination of surface waters by sewage is also a

frequent cause of trouble from this source. Probably the best and most commonly used reagent to counteract the tendencies of these acids is sodium carbonate, or commercial soda ash. Sufficient soda ash should be fed to waters containing these acids to make it thoroughly alkaline; that is, so that the water will take on a pink color when a test drop of phenolphthalein solution is placed in it.

Organic acids are encountered even more frequently than sulphuric acid and are the development of the natural decomposition of vegetation, sewage, etc. These organic acids are especially dangerous when exposed to the heating action of the boiler, where air and gases are liberated, passed on with the steam and finally appear in the condensed water, imparting a peaty odor to the ice. The air and gases will also increase corrosive tendencies wherever they appear. Probably the most practical method of eliminating the source of trouble is by preheating and agitating the water in an open tank or open heater where the air and gases will be driven off before the water passes to the boiler and piping system. Then if the water is kept alkaline by means of soda ash, harmful influences from this source will be effectively overcome.

Formation of Hydrochloric Acid

Corrosion is often set up, due to the acids developed by the decomposition or dissociation of the mineral salts contained in the water, such as magnesium chloride and sodium chloride (forming hydrochloric acid) and magnesium sulphate and calcium sulphate (forming sulphuric acid). This decomposition usually requires the presence of high temperatures, such as occasioned by high boiler pressures. Magnesium chloride, for example, under the influence of heat dissociates and liberates hydrochloric acid; where this action is found to occur, the relief again lies in the addition of sufficient quantities of soda ash to take up this free acid; that is, sufficient to render the water alkaline. In this connection it should be remembered that the composition of the water is often such that any free hydrochloric acid thus liberated will be entirely absorbed by the other carbonate and mineral salts contained in the water, such as calcium carbonate, etc. In other words, while the magnesium chloride and sodium chloride may often appear in the analysis of the water, the water will not always actually prove corrosive because there is also present in the water sufficient other mineral salts to counteract the acid influence.

Electrolytic and Galvanic Action

Electrolytic action is another source of trouble from corrosion in pipe lines of all kinds, this action being set up by the presence of stray current from the electrical system, such as from improperly grounded motors or generators, from motors direct-connected with brine pumps, suspension of electric lighting wires on pipe lines without proper insulation, poorly installed electrical conduits, etc., as well as from outside sources such as trolley-line circuits, etc.

The passage of electric currents through a piping system embodying two or more dissimilar metals has been found to materially hasten any corrosive tendency, and this is true even though there be currents of very low potential. Proper insulation, care in making all electrical installations and connections, is of course the only remedy in such cases, where the trouble can be traced to this source.

Galvanic action is often set up in apparatus due to the particular composition of the metals of which it is composed. Take the condenser tube for example: It is usually made of a mixture of copper and zinc, and it frequently happens that the mixture of metal from which the tubes are made is not of a thoroughly homogeneous nature—that is, not completely mixed—and the various metals do not lose their identity. Consequently, the texture of the alloy or composition is such as to expose on the surface of the tubes mechanically mixed (but not completely combined) copper and zinc. These two metals when brought into contact with the circulating water, which usually contains mineral salts of some kind, set up an electro-voltaic action, resulting in the eating away of the zinc from the mixture. In refrigerating plants, for example, the strong brine solutions conveyed act as an electrolyte to a very marked degree in setting up galvanic action.

The usual method of overcoming galvanic action is to insert in various parts of the system pieces of metal (such as wrought iron in the case of surface steam condensers) which are electropositive to the metals being attacked.

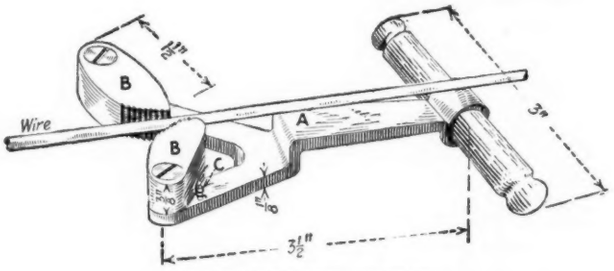
It has been found that where metals are in a constant state of strain or stress, especially torsional stress, the attacks by corrosion are more violent and persistent than ordinarily. High temperatures have also been found to accelerate corrosive action.

The cutting effect of rapidly moving bodies of air, steam, water or liquids increases the tendency to corrosion, especially in short-turn bends or in pipe lines that are too small and cause excessive velocities. A microscopic study of the surface of a pipe will show an area made up of irregular projections and pockets which are worn deeper and deeper by what may be termed the sandblast action of rapidly moving liquids, especially when the liquid, air or gas contains finely divided particles of mud and grit.

Home-Made Wire Puller

By M. P. Bertrande

The handy little tool shown in the figure is intended to take the place of a pair of pliers or do away with the necessity of winding the wire around a screwdriver to draw it tight. Furthermore, considerable pull can be



WIRE-PULLING DEVICE

applied with one hand. The body *A* is made of ⅛-in. steel, to which are fastened two steel jaws *B* ⅜ in. x 1½ in., held close by the wire spring *C*. The grip and application can easily be seen from the illustration.

The Electrical Study Course—Size of Conductors

Methods of determining the size of conductors, to transmit a given current with a specified voltage drop, are given, and problems worked out showing their application to specific conditions.

IN GENERAL, circuits that are not over 400 or 500 ft. in length can be loaded up to capacities prescribed by the National Board of Fire Underwriters' table. Beyond this length the size of conductors is usually based on a given allowable voltage drop. Just what the allowable voltage drop is, is a question that is determined by conditions. For a lighting circuit it should not be more than about 3 volts and for motor work in general not in excess of 5 per cent. of the line voltage, although there are cases on record where the drop in the feeders has been as high as 25 per cent. This last value would under no condition be considered good practice. In long, high-voltage transmission lines the allowable drop varies from 5 to 10 per cent., 7.5 per cent. being considered a good average.

Economical Size of Conductors

The question as to just what is the most economical size of conductor may appear at first thought easy of determination. This, however, has proved to be one of the problems that no general rule can be evolved for. However, one thing may be said about it: As long as the returns on the power saved will pay the cost of the additional capital invested in transmission equipment, it is good engineering practice to increase the size of the conductors. The return on the power is affected by a great many factors, such as the cost of the power itself, which may vary from a fraction of a cent to 8 or 10c. per kilowatt-hour; or the character of the installation—it may be a new water-power installation where there is an excess of power. Then no matter what may be the price per kilowatt-hour, it may be good practice to let the waterwheels do a little more work by allowing a greater drop in the line and keep the amount of capital invested in the original project down to a minimum, which may be increased as the load increases on the station, by the addition of a second line. These and many other conditions enter into the most economical size of conductor in a transmission line. But for distributing circuits for lamps and motors, the size is generally determined by the voltage regulation required.

Voltage Regulation of Different Circuits

On lighting circuits the voltage regulation should be very close, while on motors it will depend somewhat upon the speed regulation required, the type of motors, etc. However, as previously stated, this should not be much in excess of 5 per cent. To determine the size of a conductor in a distributing system to transmit a given power, it is necessary to know certain factors; namely, the value of the current in amperes, the length of the circuit one way, and the allowable voltage drop.

For example, consider a case where 175 amperes is to be transmitted 625 ft. one way, with 3.5-per cent. volts drop in the line, the voltage at the source being 236. The voltage drop in this case is

$$E_d = \frac{E \times \textit{per cent. drop}}{100} = \frac{236 \times 3.5}{100} = 8.26 \textit{ volts}$$

This 8.26 volts is used up in causing the 175 amperes to flow through the two conductors, leaving an available voltage E_a at the load equal to the difference between the total volts E and the volts drop E_d, or $E_a = E - E_d = 236 - 8.26 = 227.74$ volts available at the load, as shown in Fig. 1. This gives a condition similar to that shown in Fig. 2, of three resistances in series, two of them being the conductors and the third the load. We have learned in previous lessons that the resistance of any circuit or section of a circuit is equal to the volts impressed upon the circuit, divided by the current. Hence in our problem the allowable resistance of the two conductors is equal to volts drop in the conductors, divided by the current flowing through them. Therefore the resistance of the two conductors is

$$R = \frac{E_d}{I} = \frac{8.26}{175} = 0.0472 \textit{ ohm}$$

That is, the two conductors may have 0.0472 ohm resistance and cause only 8.26 volts drop when 175 amperes is flowing through them.

The resistance of 0.0472 ohm is that due to the outgoing and return conductors, each of which is 625 ft.

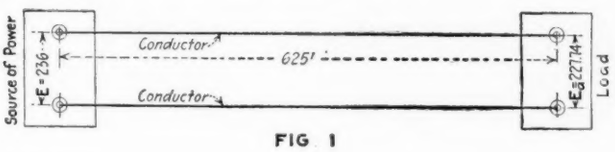


FIG 1

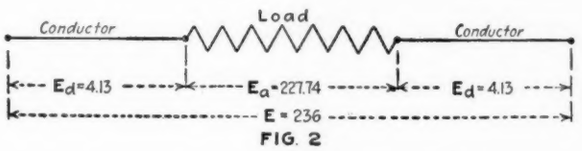


FIG. 2

FIGS. 1 AND 2. LAYOUT OF CIRCUIT

long, or a total length of 1250 ft. The resistance for 1000 ft. equals the total resistance R multiplied by 1000 divided by the total length L. Hence,

$$\textit{Resistance per } 1000 \textit{ ft.} = \frac{R \times 1000}{L} = \frac{0.0472 \times 1000}{1250} = 0.0378 \textit{ ohm}$$

In the sixth column from the left-hand side of the wire table given in the last lesson will be found the resistance per 1000 ft. of different size conductors. The size of wire may be determined in our problem by referring to the table and finding a conductor that has a resistance of 0.0378 ohm per 1000 ft. The nearest resistance per 1000 ft. that we find in the table is 0.0350. This is for a 300,000-cir.mil. conductor and would be the size that must be used if the volts drop is not to exceed 8.26 when 175 amperes is passing through the circuit.

The resistance of the conductor chosen is slightly less than that calculated, consequently the volts drop in the line will be less. With 175 amperes flowing in 1250 ft. of 300,000-cir.mil. conductor, the volts drop will be, resistance per 1000 ft. $\times$ total length in feet $\times$ total current $\div$ 1000, or $0.0350 \times 1250 \times 175 \div 1000 =$ 7.66 volts, against 8.26 calculated as the allowable.

Another thing that we must keep in mind is the requirement of the National Board of Fire Underwriters' regulations, and see to it that a size of conductor is not used smaller than that prescribed in the table. Referring to the table for the size of conductors to carry 175 amperes, it is found to be No. 000 for rubber-covered wire and No. 0 for other insulations. In the case of the No. 0, it is allowed to be loaded up to 200 amperes, but No. 1, the next size smaller, will carry only 150 amperes, therefore No. 0 will have to be used if the size of wire is chosen according to the table. Taking the case of the No. 000 rubber-covered conductor, which can be installed for 175-ampere load, it has a resistance of 0.0625 ohm per 1000 ft., and with 175 amperes flowing through 1250 ft. of this conductor, the volts drop will be $0.0625 \times 1250 \times 175 \div 1000 = 13.67$ volts, which is considerably in excess of what was decided to be the allowable drop. Consequently the size conductor calculated will have to be used.

Another method of determining the size of the conductors, in which no wire table is required, is by the formula,

$$Cir.mils = \frac{21.4DI}{E_d}$$

where D equals the distance one way in feet, and I and E_d as already indicated. In this problem

$$Cir.mils = \frac{21.4 \times 625 \times 175}{8.26} = 283{,}369$$

This value would be the exact size. However, the nearest standard size is 300,000 cir.mils in cross-section, and is the size of conductor that will have to be used.

In study problem No. 1, given in the last lesson, if the conductors had been the same size in both cases, the resistance would vary directly as the length and would have been determined by the proportion, 400: 1000: : 0.45: x, or $x = \frac{1000 \times 0.45}{400} = 1.125$ ohm. In this problem the cross-section of the conductor is decreased by 2 (from 65,000 to 32,500 cir.mils), consequently the resistance for a given length will be doubled, or the resistance in this problem is $2 \times 1.125 = 2.25$ ohms.

In the second problem if the conductors were of the same size in both cases, the weight would vary directly as the length, and the weight of the second conductor could be determined by the proportion 750: 1200 : : 168: x, from which $x = \frac{1200 \times 168}{750} = 268.8$ lb. The diameter of the conductors in this problem is increased from 350 to 922 mils, hence the weight will also be increased, owing to the increased size of the conductors. The cross-section of a round conductor varies directly as the square of the diameter. Hence the weight of the 1200-ft. conductor will be $350^2 : 922^2 : : 268.8 : x$, from which $x = \frac{922 \times 922 \times 268.8}{350 \times 350} = 1865.3$ lb.

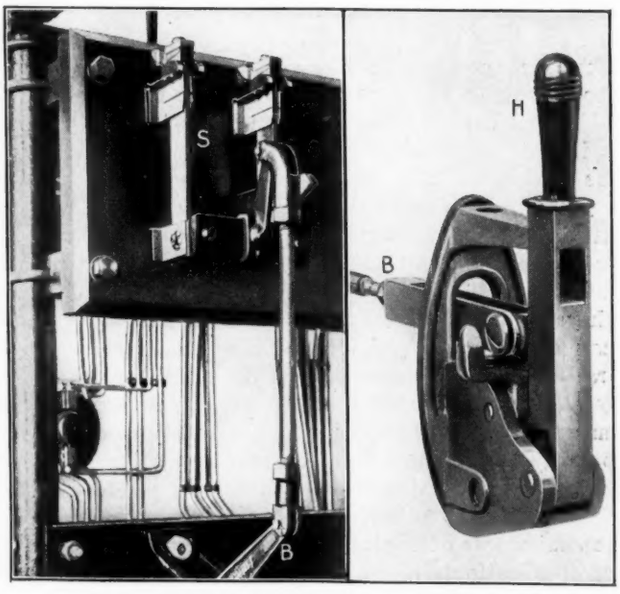
1. The resistance of 650 ft. of copper, 83,690 cir.mils in cross-section, is 0.0818 ohm. Find the resistance of 1500 ft. of round copper, 707 mils in diameter.

2. Find the size of the conductors in circular mils required to transmit 235 amperes 875 ft. one way, allowing a drop of 4.5 per cent. in the line. The voltage at the source is 575. Also find the resistance of the line, resistance per 1000 ft. of conductor, the voltage at the load and the diameter of the conductor in mils.

Field Switch To Be Mounted on Rear of Switchboard

It is well-known that during the starting period the field coils of a synchronous motor act similarly to the secondary coils of a transformer, when the machine is brought up to speed on the alternating-current circuit. This induced voltage reaches considerable value; and if the field switch is mounted on the front of the switchboard, it is a menace to the operator and, to say the least, is not in the interest of "Safety First." To overcome this difficulty, the General Electric Co., Schenectady, N. Y., has developed a "Safety First" type of field switch that is mounted on the back of the switchboard, as shown in the illustration. This arrangement locates all live parts where there is no danger of the operator coming in accidental contact with them when performing his duties at the front of the board.

The equipment consists of an operating handle H similar to an oil circuit-breaker lever, mounted on the front of the board, and the switch proper S mounted



SAFETY-FIRST FIELD SWITCH

on a slate base, which is supported on a framework back of the switchboard. The switch is connected mechanically to the operating handle by means of connecting-rods and bell hangers B. This type of field switch is used also in connection with alternating-current generators when it is desired to reduce risk to a minimum.

When solenoid-operated field switches are used in the field circuits of synchronous motors started from the alternating-current source, they are ordinarily made of two single-pole elements with independent closing and opening coils. Both poles are closed simultaneously, but

in opening, one pole precedes the other. The first pole to open connects the discharge resistance across the field, the other pole opening immediately after and interrupting the discharge circuit and entirely disconnecting the field circuit.

On synchronous motors utilizing 250-volt excitation it is the practice to start with the field coils short-circuited through the discharge resistance. In such cases a double-pole switch, as in the illustration, is provided to short-circuit the field through the discharge resistance during the period of starting.

Solenoid-operated field switches for synchronous motors started with the field coils short-circuited are double-pole with a common closing coil and common opening coil. No provision is made for automatically interrupting the discharge circuit after the switch is opened, although the discharge blade can be opened by hand.

Notes on the Pitot Tube

By W. V. White

The pitot tube is not a new device, but it is used by only comparatively few persons, and there is considerable mystery thrown around it by some, but the principle is fairly well laid down in most handbooks.

It requires two "sampling nozzles" to be put into the pipe about as shown in Fig. 2, the two openings being near together, but not so close as to interfere with each other. The bent tube should be pointed or filed off to a sharp edge. The outer ends of these tubes will show different pressures. That shown at the straight one is called "the static head" and is less than at the bent one, which is called the "velocity head." The difference between these is just what is desired to be known. The first impulse would be to put pressure gages on these tubes, but as the difference is usually very small, another device is preferable; namely, the U-tube. Fig. 2 shows a device designed by me that is convenient and works very well. A short length of ½-in. iron pipe in the center has two gage-glass sets screwed into the tees at its two ends and ¼-in. pet-cocks, as shown, with unions as needed. To operate, close all lower valves and open all top valves. Then carefully open the two bottom cocks and allow water to one-half fill each glass; next fill each glass with some free-flowing machine oil through the top cocks. This will also fill the iron pipe with oil, which may be needed later, as by manipulating the various valves the oil can be forced into the glasses establishing the water and oil level or meniscus where desired. After filling with oil, close all top and bottom cocks and have all wood-handled valves open; the meniscus will be level, as seen. Then close both bottom wood-handled valves and turn on the water from the tubes. The oil will rise in one and lower in the other glass. The difference in level between (measured in feet or fractions of a foot) is the difference between "static" and "velocity" head.

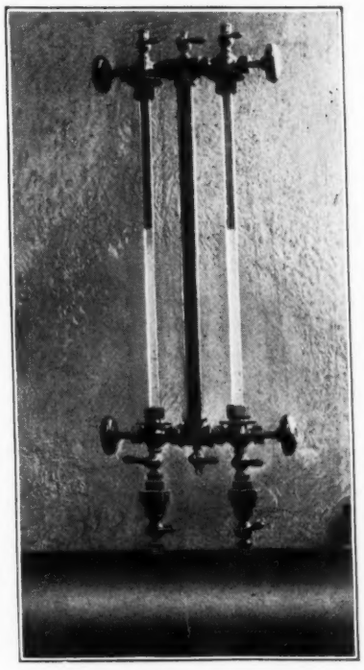


FIG. 1. UNIQUE U-TUBE

Having this figure, the velocity v of the flow in feet per second in the pipe is obtained by the formula,

$$v = 8.03 \sqrt{h}$$

in which v = velocity of flow in feet per second, and h = head or difference (in feet) between "static" and "velocity" head.

Then having the rate v and the diameter of the pipe, the cubic feet or gallons flowing per minute or hour can be easily obtained. The 16-in. glasses shown can measure as high as 555 ft. per min. ($8.03 \sqrt{1.33} \times 60 = 555$) or it can be read as low as ¼ in. on the glasses, showing a rate of 1.15 ft. per second ($8.03 \sqrt{0.0208} = 1.15$), or 69 ft. per minute.

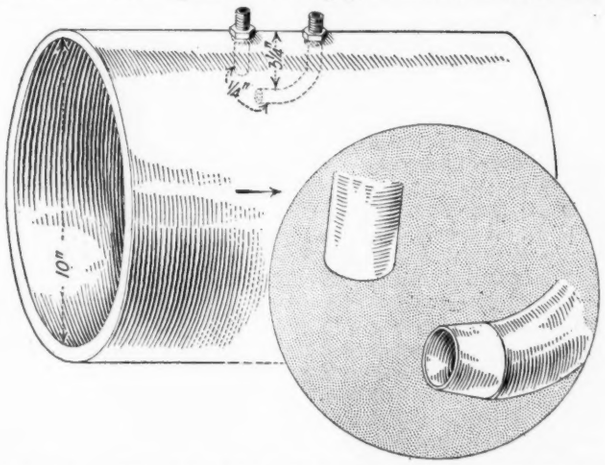


FIG. 2. FORM AND LOCATION OF SAMPLING NOZZLES

The insertion of the tubes in the pipe is a matter of some possible controversy, as the flow of water is not the same in all parts of the pipe. Opinions as to where the average conditions appear all seem to hold that about one-third the diameter of the pipe is near enough, so the velocity tube can safely set that much into the pipe.

This method of measurement has been checked by several others and has the reputation of being correct to within 3 per cent.

In a large generating station having a good load factor, efficient turbine units, good superheat and condensing conditions, and coal at normal prices, the generating costs per unit may be taken, says Mr. J. Shepherd, in a paper read before the Institution of Electrical Engineers, to be as follows: Salaries and wages, 0.06c.; coal and ashes, 0.32c.; oil, waste and stores, 0.008c.; repairs to plant and buildings, 0.024c.; total, 0.412 cents.

The efficiency of a boiler and consequently its economical operation, depend upon the right proportion of air admitted to the furnace, or upon a proper draft.

Tom Hunter, Hoisting Engineer

By WARREN O. ROGERS

We go to the Calumet & Hecla stamp mill, where pumping engines up to 70,000,000 gal. per 24 hours are seen. The designs of these pumps are different, with the Leavitt rocker-arm type predominating.

THE next morning Hunter and I took a trolley car at Calumet for Lake Linden to look over the Calumet & Hecla stamp mill. "I don't suppose," said Hunter, "that we shall see very much difference between the method of stamping and what we saw at the Champion mill, with the exception that the mill is much larger. We will, however, see some pretty large pumps there, as a large quantity of water is used first and last. You know that the Calumet pond pumping plant," see Fig. 1, "where we stopped last Sunday, is as large as some plants used to supply a whole town with water, and yet those four pumps merely supplied water to the Calumet & Hecla mine property for fire protection, air cooling and for cooling the air-compressor cylinders. Those pumps are good for considerable

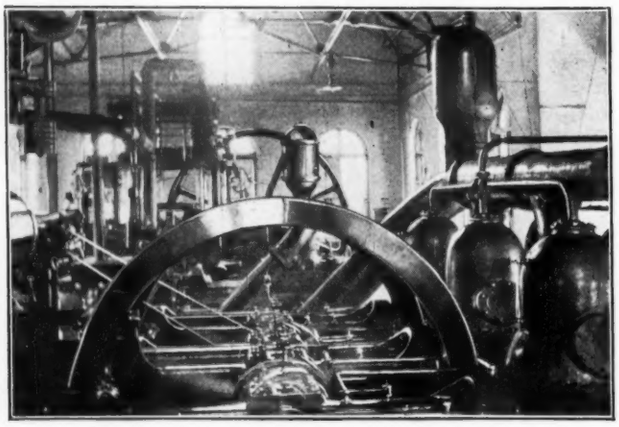


FIG. 1. THE 3,000,000-GAL. PUMP AT THE POND PUMPING STATION

water. For instance, the vertical rocker compound Minnehaha, as it is named, has a capacity of 3,000,000 gal. per 24 hours with a 100-ft. head.

"That engine, I believe, was the first one installed at that plant for supplying condensing and feed water to the hoisting engines at the Calumet & Hecla mines. The interesting feature of the engine is that the connecting-rod is on one side of the beam." This is shown in Fig. 2. "The pump plungers connected to the crosshead and a crank rod from the rocker extended to the flywheel crank.

"The small tandem-duplex pump is good for 10,000,000 gal., the large slow-speed one can supply 2,000,000 gal., and the triple-expansion pump has a capacity of 15,000,000 gal. against a 100-ft. head. So you see that little plant has a total capacity of 30,000,000 gal. of water each 24 hours. Of course they don't use that much, but the pumps are there if wanted."

"Yes, and the longer I stay around these mines the plainer it becomes why some of them have a hard time getting along with the price of copper down. One would hardly think that it would require such a large pumping plant for supplying the water used at the mines. I suppose that the pumps at the stamp mill will have still larger capacities."

"I believe I can show you about the largest pumps in this region," replied Hunter. "I remember the Michigan, one of the largest, has a capacity of 60,000,000 gal. of water per 24 hours with a 90-ft. head. It is a vertical triple-expansion engine with 18-, 27¾- and 48-in. cylinders and 90-in. stroke and two 34 x 48-in. water plungers. It was designed to run at 30, but usually ran at 28½ r.p.m. with a head of about 40 feet.

"When the first pumping engine was designed for the Calumet & Hecla Mining Co." continued Hunter, as we left the car at a turn at the mill, "they were inverted, with the high-pressure cylinder inclined for the purpose of having the cylinders as near together as possible, and thus reducing certain losses. Between the rear ends of the cylinder there was a single valve that served as both high-pressure exhaust and low-pressure inlet. At the piston end of the cylinder there were two valves which moved simultaneously, one being the high-pressure exhaust and the other the low-pressure inlet.

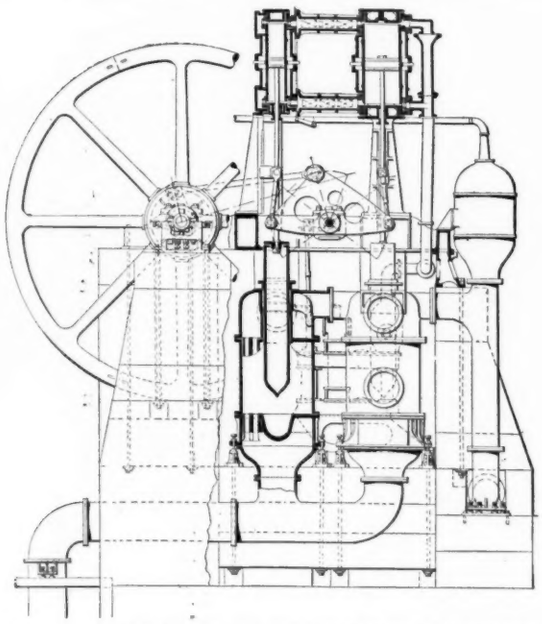


FIG. 2. ELEVATION OF THE ROCKER-COMPOUND PUMPING ENGINE

The old pumping engine Ontario here at the stamp mill was designed about the same time. It has the high-pressure cylinder inclined and has no reheater."

It was impossible to photograph the engine, but Fig. 3 shows its general design. This engine was run with a steam pressure of 185 lb.

"The Michigan pump is of different design," continued Hunter, "and is supported by wide straddling cast-iron columns." See Fig. 6. "The pump cylinders, which were cast in gun metal and made oval at the valve level for accommodating the valves, were 9 ft.

10 in. wide the narrow way and 14 ft. 2 in. the other way."

When we got to the stamp mill I found that the larger pumps, Figs. 4 and 5 were of the beam type, with cam-operated gridiron valves similar to the other Leavitt-Morris units we had seen. The low-pressure piston connected to one end of the rocker arm, and the high and intermediate pistons connected to the other end. A crank rod from the top of the rocker connected with the flywheel shaft. The valves were operated by a cam-shaft that received its motion by means of gears from the flywheel shaft. The pump Michigan (Fig. 4) supplied water to the stamp mill. In an adjoining pump-room we found several older units. One was a horizontal pump, gear-driven by a Brown horizontal steam engine (Fig. 7), the only one of its kind that we saw at the mines. The pump had a capacity of 20,000,000 gal. per 24 hours with 72-ft. head. A vertical compound pump with a capacity of 20,000,000 gal. seemed to be held as a reserve. Besides the flywheel, the pump carried a rope-drive pulley for carrying 20 ropes, English style, to a centrifugal pump of 60,000,000 gal. capacity per 24 hours at 220 r.p.m. and 57 ft. head. The 70,000,000-gal. vertical triple-expansion pump was also idle. This pump (Fig. 5) was designed with the walking beam at the base and the water cylinders below the floor level.

As we walked about the plant, I was impressed with the volume of water used, although only the large pump was running. However, 60,000,000 gal. per 24 hours would make quite a puddle, as I remarked to Hunter.

"When you have been through this plant, you will see where the water goes, for there are a bunch of stamps, jigs and concentrating tables. In fact, one of the determining features in fixing the site for a stamp mill is an abundant water supply. Ample space for the disposal of the tailings, or the waste from the mill is necessary, and of course the closer to the mines the better on account of the rail haulage. The water supply here at the lake is abundant, and if you traveled along its shores, you would find a number of stamp mills.

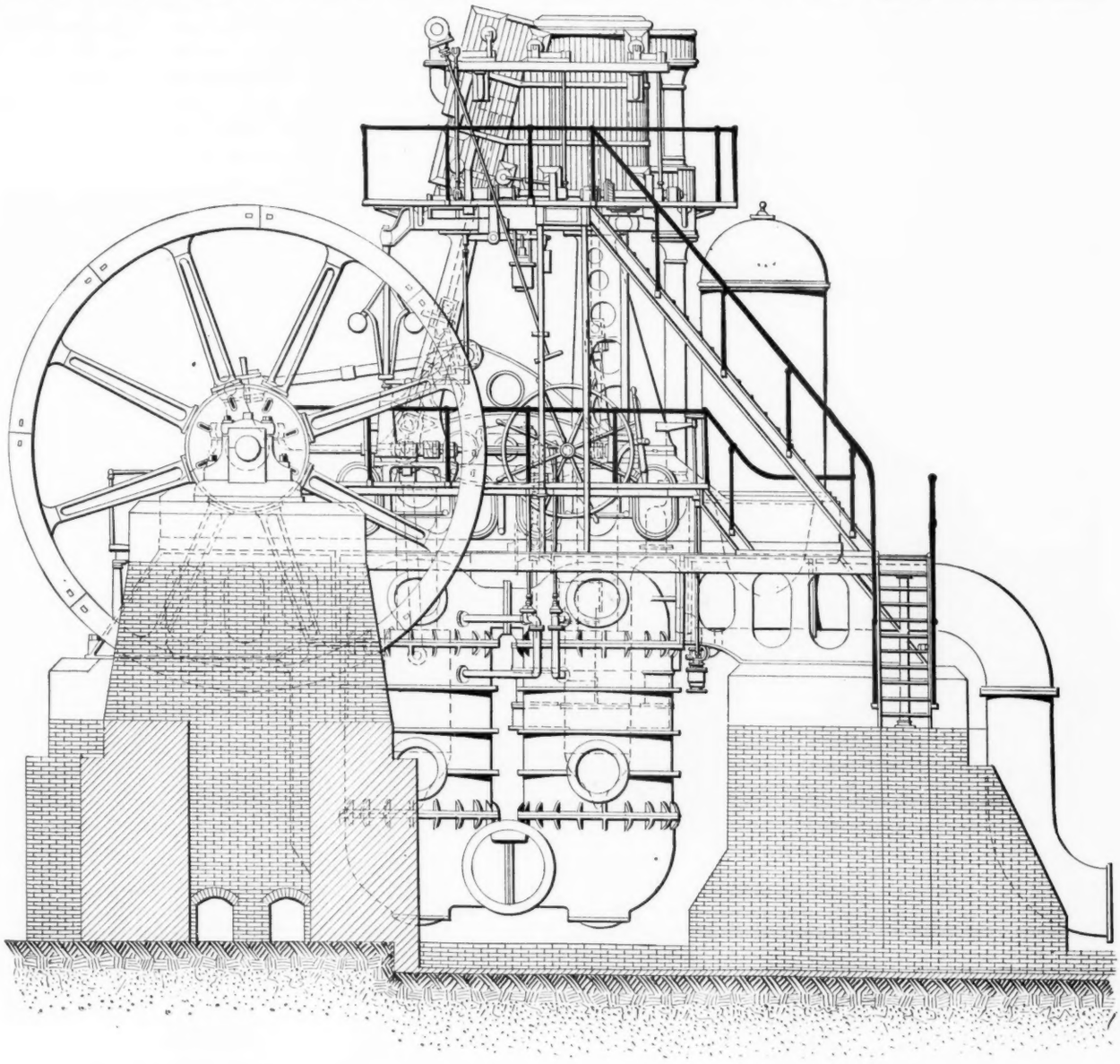


FIG. 3. SHOWING GENERAL DESIGN OF THE FIRST PUMPING ENGINE BUILT FOR THE CALUMET & HECLA CO.

"You mentioned that the pump was capable of making quite a puddle, but when you consider that it takes about 22 lb. of water per pound of rock handled, you can see that a large volume of water is required.

"These pumps here, although they have been in service a long time are much different from the early pumps, as you can readily imagine. Perhaps you don't know it, but the pump is one of the oldest machines that man has used to get rid of manual labor in lifting water. It would make an interesting study to trace the progress that has been made in the art of lifting water from one level to another from the beginning up to the present time. About the crudest form of pump that you or I have seen is what is known as the Shadoof, commonly used on the Nile River. We have seen them at farmhouses in the form of the old well sweep where a bucket is suspended from an arm that is hung from a frame, the arm being counterweighted, usually by a stone.

"Well, improved methods were devised up through the ages to Savery's, Papin's, Newcomen's and Watt's time, with which you are familiar, all of which belongs to ancient history.

"There wasn't much done in this country with pumps until H. R. Worthington, about 1841, brought out his first steam-actuated boiler-feed pump. I believe that the steam supply to this pump was controlled by a float in the boiler so that when the water got low the pump would start automatically and run until the water level lifted the float enough to cut off the steam.

"About 20 years later the development of pumping engines had so progressed that the City of Cincinnati put in a pump of 9,600,000-gal. capacity per 24 hours. It had no beam, such as these engines we have seen today, but was direct-acting. It was one of the largest then in use. The first large compound pumping engine that Mr. Leavitt had anything to do with, so far as I know, was built for the City of Lynn, Mass., in 1873. It had two inclined steam cylinders and a water cylinder that discharged on each stroke, although it was single-acting on the suction side. This pump had a flywheel and beam. Each cylinder connected to one end of the beam, and a connecting-rod reached from one end of the beam to a crank of the flywheel shaft, and from the other end of the beam connection was made to the pump plunger. In this engine the gridiron type of valve was used, operated by cams. So you see, Mr. Leavitt kept largely to his original idea in the development of his other pumping units.

"I believe the first triple-expansion pumping engine was built for the City of Milwaukee. I am not sure who designed it, but I believe it was Mr. Allis. It was vertical and was fitted with Corliss valve gear and had a capacity of 6,000,000 gal. per 24 hours. When one thinks of a pumping engine nowadays, his mind reverts to such units as are installed in the Philadelphia water-works plant, where each of the newer pumps has a normal daily capacity of 20,000,000 gal. and there are 12 of them.

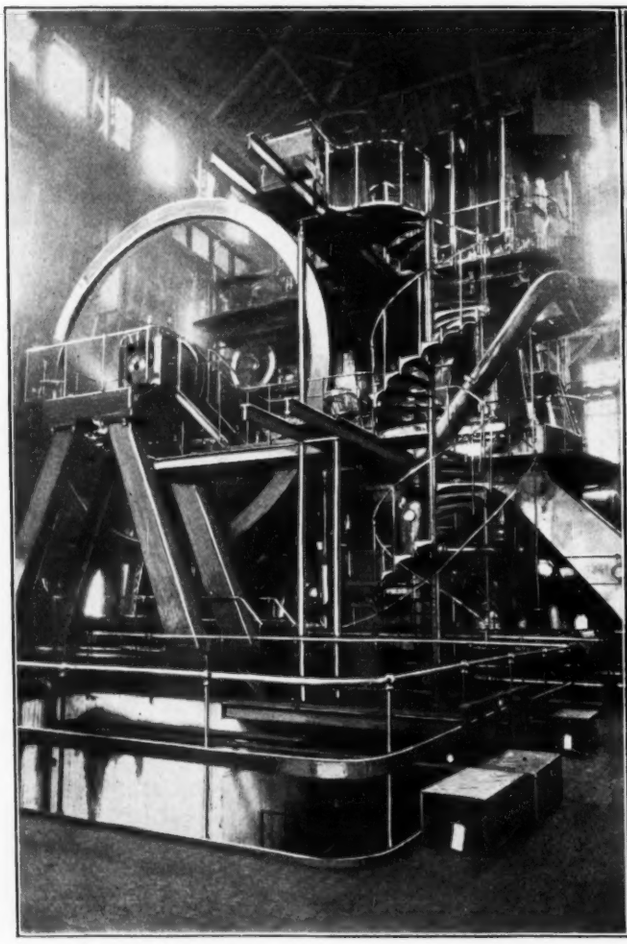


FIG. 4. A 60,000,000-GAL. PUMP AT STAMP MILL

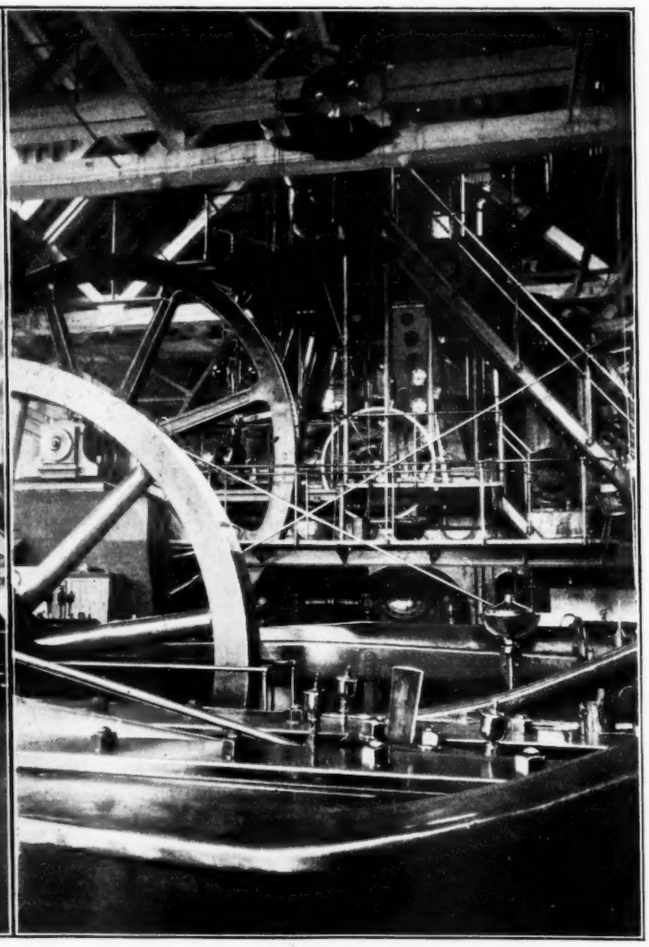


FIG. 5. OLD PUMPING PLANT AT STAMP MILL

"These are some pumps," replied Hunter, "and there are a lot of others just as good and larger."

"You spoke of the disposal of tailings, What are they?" I asked, changing the subject, as we made our way to what was called the sand wheels.

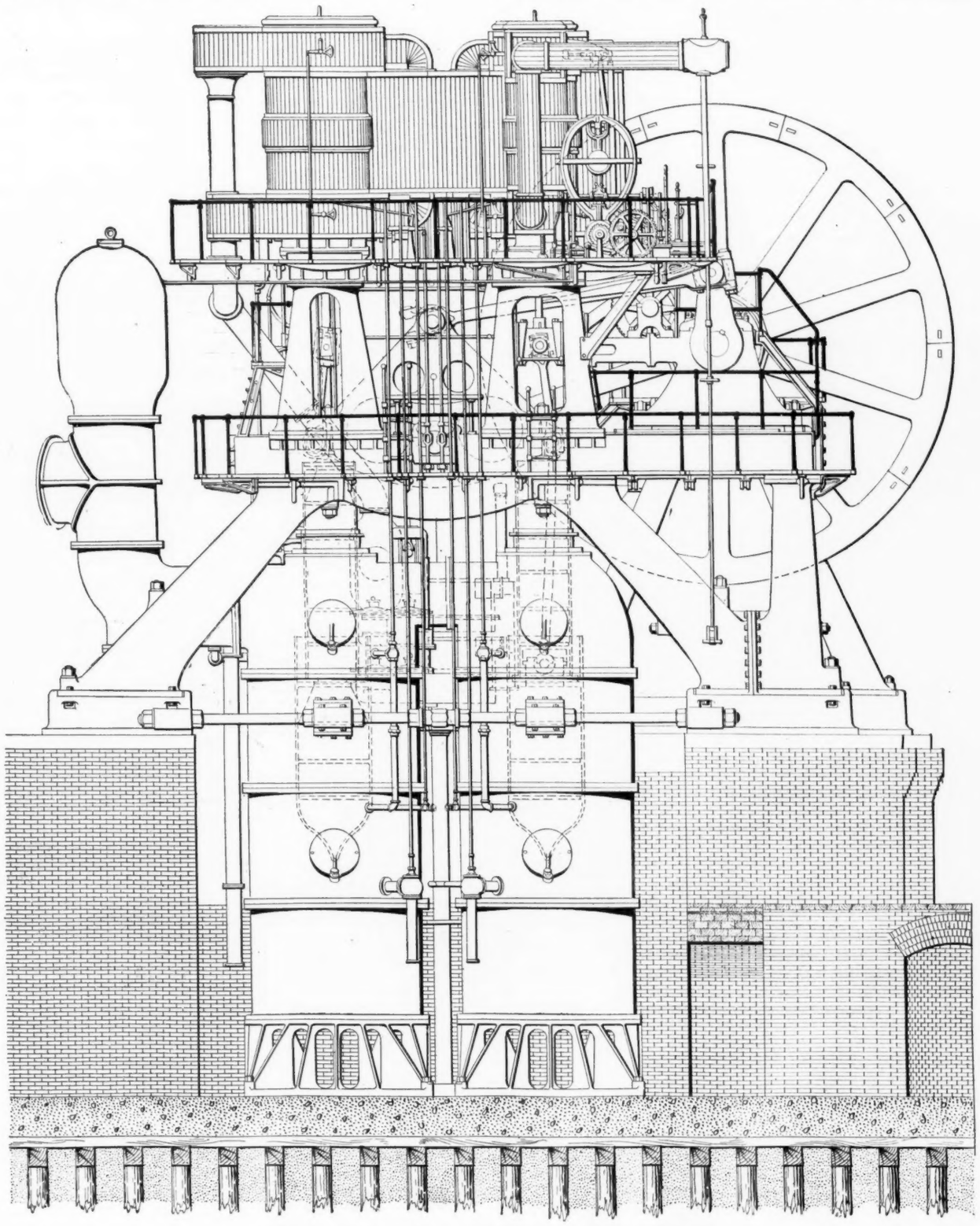


FIG. 6. ELEVATION OF MICHIGAN PUMPING ENGINE

"Why, you have seen tons of them," replied Hunter. "Tailings are in the form of fine gravel, and are what remains of the copper rock after the copper has been extracted. They are handled by flushing with large volumes of water through troughs, or launders as they are called. These should have a drop of at least ⅜ in. per foot. If the mill is at an elevation above the discharge point, the same as we found at the Champion mill, the tailings disposal is simplified. When the mill is on practically level ground with scarcely any elevation above the point of disposal, if at a distance, then

the launders have to be elevated in order to have the tailings flow by gravity to the point of discharge. If this is not done, some mechanical means of securing sufficient height becomes necessary.

"Now you can see that we are but a few feet above the lake level and mighty close to the shore line. The original available area for tailings disposal soon gets filled in, and of course it becomes necessary to raise the height of the launders to allow for the proper drop. This was done here, and as a means of elevating the tailings large wheels, called sand wheels, were installed to lift the sand and water to the intake end of the launders. The largest of these wheels is 62 ft. 6 in. diameter and 11 ft. wide. However, you won't be able to obtain a satisfactory photograph of one, because they are boxed in."

Fig. 8 is an elevation of one of the sand wheels. I found that Hunter was right about photographing, as it was necessary to go up several flights before we got to the top. The operator opened up doors here and there so that a fairly good idea was obtained of the design of the wheel. It was built along the lines of a bicycle wheel and with its baseplate and supporting columns weighs about 500 tons. The shaft is 23 ft. 6 in. in diameter, is 25 ft. long, has a 16-in. hole through the center and weighs about 21 tons. On the shaft are hubs each weighing 10 tons, and forty 4-in. spokes radiate from each of these hubs and terminate in blocks that support the inner rim. The rim of the wheel is made up of an inner and an outer ring. The outer ring has 520 teeth cut in it for driving purposes, and on each side of this rim there is an extension about 5 ft. wide, and to these extensions 275 rectangular iron-plate boxes are secured, each 3 ft. wide and 4 ft. 6 in. long.

In operation the wheel makes about four revolutions per minute, but at that the rim speed at the inner edge of the buckets is around 11 ft. per second. In revolving the bottom of the wheel rim passes through

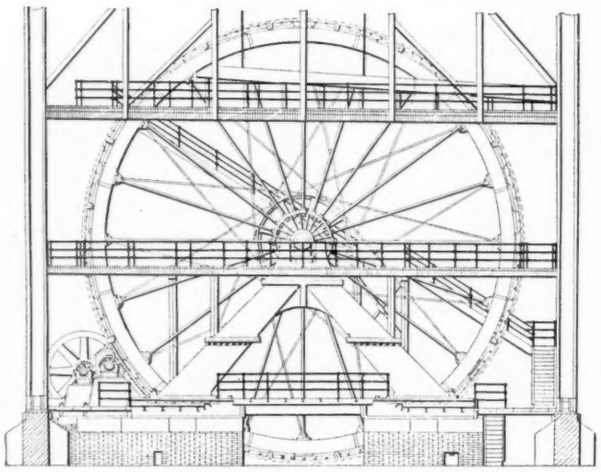


FIG. 8. DETAILS OF ONE OF THE SAND WHEELS

a shallow pit into which the tailings from the mills discharge. As the wheel revolves, the buckets are filled with water and tailings. The discharge is at the top into a trough at each side of the wheel which discharges into the launders. The wheel is driven by a motor, rope drive and a pinion gear. The wheel elevates the water and sand 54 ft. at a rate of 40,000,000 gal. of water and 8000 tons of sand in 24 hours. Three smaller sand wheels are 51 ft. 4½ in. diameter; and each handles 30,000,000 gal. of water and 4000 tons of sand each 24 hours.

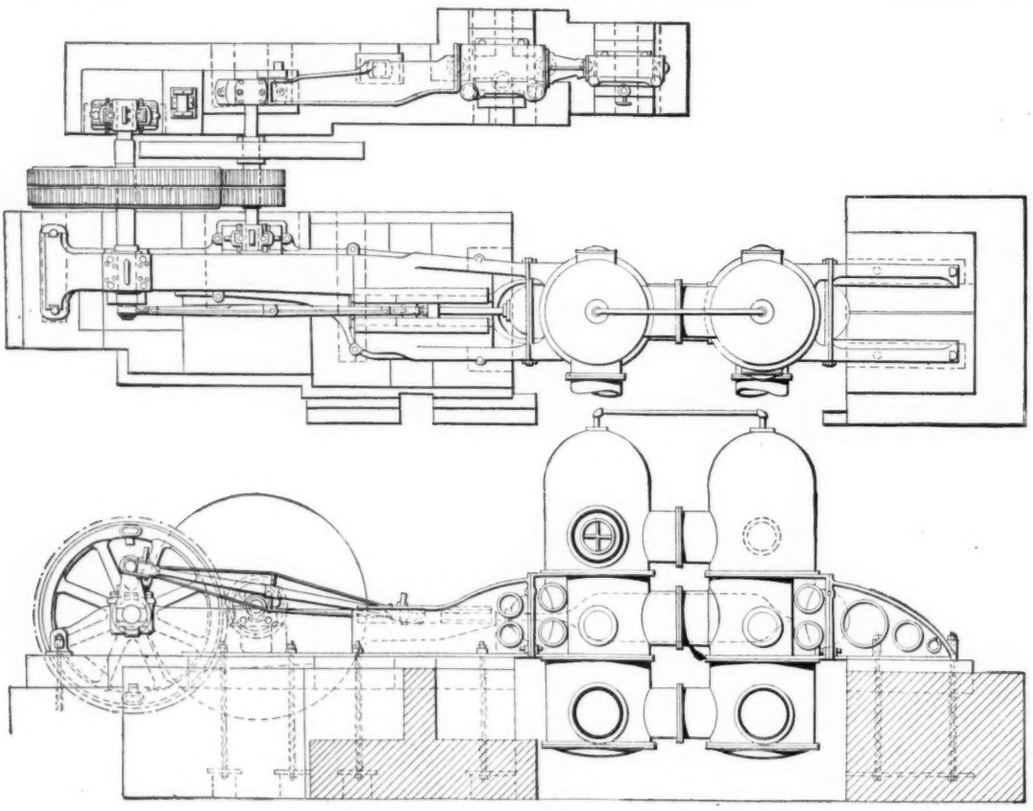


FIG. 7. SIDE VIEW OF ENGINE-DRIVEN PUMP

Coal and Price Regulation

By Henry Misostow
Smoke Inspection Department, Chicago, Ill.

There is no intention to criticize what has been done in the way of regulating coal prices or to obstruct what might be done, but to emphasize the importance of the subject, as well as furnish information that might be of importance in the case.

The State of Illinois is one of the largest coal-producers in the Union, and a great number of small communities depend entirely on coal mines, just as all industries of the state indirectly depend on coal for existence. Therefore coal-price regulation is of vital concern to the state at large.

A few years ago the writer visited a large number of coal mines in Illinois to ascertain if smokeless fuel for domestic and industrial purposes, to be used in Chicago, could be produced from Illinois coal. The investigation brought out the following facts: (1) There were a large number of independent coal-mine owners; (2) coal fields were not monopolized and keen competition existed; (3) retail dealers of large cities were strongly organized and mine owners not connected with them had a hard time in disposing of their product; (4) large coal consumers practically dictated the price they would pay and scarcely paid anything in excess of the cost of production; (5) all profits of coal miners were made on domestic and small consumers; (6) coal as a source of heat was cheaper by many times than natural gas or oil; (7) if large consumers were compelled to pay their share, the price to the small consumer could be greatly reduced.

The effect of these existing conditions may be summarized as follows: (1) In the case of railroads cheap coal encouraged lavish waste; (2) large power-producing corporations, or so-called "central-station plants," were enjoying undue advantage over small consumers in the same line of business, or privately owned plants, thereby creating unfair competition; (3) the main burden was carried by the domestic and small consumer.

Coal Cheaper Than Other Fuels

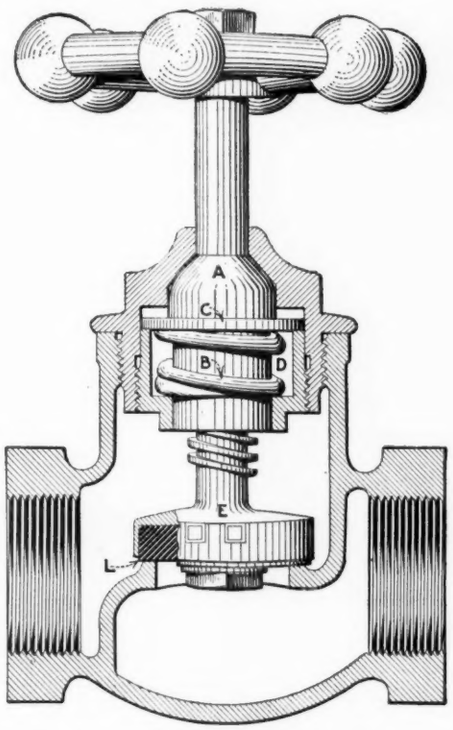
At present coal, as high as it is, is much cheaper than any other fuel used in the industries, and yet price regulation is of great importance and to the interest of the community. The coal bill may be reduced in two ways: First, by using coal properly and using less of it; second, by paying less per ton. Intelligent use on the part of the consumer will tend to conserve and enrich the community at large. Paying less for coal will decrease the amount of money changing hands and the state or country at large will not be affected, as the sum of wealth will remain the same unless the price of coal gets to a point to hinder industry. The price regulation of coal must have both these objects in view to be of real benefit to the people at large.

To make price regulation effective and just, the following points must be considered: (1) Price regulation must include all fuels—coal, crude and fuel oil, gasoline, kerosene and alcohol, and price must be based on the heat content that can be utilized; (2) the same grades of coal at the mines should be sold at the same price to all customers whether large or small; (3) the price should be high enough to compel proper effort to save and insure the stability of the industry: (4) eliminate all competition and oppression of small mine owners; (5) divorce the coal industry from the large consumers' influence, be they railroads or large central stations.

From the foregoing can be seen the complexity and importance of the subject, and therefore it must receive full consideration to insure justice to all.

Sandusky Packless Valve

The absence of packing around the stem of a valve is a feature that appeals to engineers who have for years put in their spare time repacking leaking valve stems. Another such valve is being manufactured by the Sandusky Packless Valve Co., of Sandusky, Ohio. In place of the usual packing nut or gland the stem



SANDUSKY PACKLESS VALVE

and the cap work in contact, forming a ground joint at *A*, the cap being provided with a flat seat and the valve stem with a rounding surface. A spiral spring *B* presses against the flange *C* which is integral with the valve stem, and holds the ground joint firmly together. A spring nut *D* serves to hold the lower end of the stem central in the body and also comes in contact lightly with the flange *C* so that the ground joint remains tight regardless of any downward or side pressure on the handwheel.

The lower end of the stem is made with a double left-hand thread. The lifting of the seat is done by the threaded stem of the disk holder, which works in the threads in the lower end of the upper stem. Guides on the disk holder *E* engage a guide on each side of the body and prevent the disk holder from turning when the handwheel is turned so that the two threads must engage and raise the disk from its seat. This type of valve is manufactured for both high and low pressures, including radiator valves.

Some Troubles of Steam Turbines

By EUGENE BAK

Describes some troubles experienced with steam turbines, particularly with vertical machines, many of which are still in operation and about which little is now being published, though operators to whom these machines are new want to know about their operating peculiarities.

THE writer has seen a 1000-kw. vertical turbine in service slow down of its own accord, so much so that it had to be stopped altogether. After throwing in another machine to take the load, it was found that the mud carried by the steam solidified, owing to the superheat, and plugged the strainer in the steam line to the turbine. Some hours later the second turbine showed the same symptoms, but by cutting out the superheater the saturated steam washed out the material in the strainer. A boiler compound was used, which, instead of precipitating the solid matter, kept it floating on the surface of the boiler water, from which it was carried over to the turbine with the steam.

When Hydraulic Piston Sticks

Sometimes, though not frequently, you will see that with increasing load the speed drops and the admission valves do not follow the movement of the governor and therefore do not adequately open. This is a sign that the hydraulic piston (a vertical Curtis machine is being considered) is sticking or the pressure is not sufficient to drive it. In this case put a pipe wrench on the camshaft and help it turn by hand. Then try to raise the pressure and see if the valves will operate with an increased pressure. One may leave the pipe wrench on the shaft and load the end of the wrench so that it helps the hydraulic pressure to operate the valves. It is well to see that the valve rods are not covered with scale and that the stuffing-boxes are not too tight. When running in parallel, the other machine will take more load than the one with its valves sticking and the trouble is less annoying than when not running in parallel. When running in parallel with another well-governed machine, this action is negligible; but when in parallel with a slow-governing hydro-electric station, it becomes troublesome. A tight piston should move with the slightest amount of oil that the pilot valve is sending into the cylinder. If a small amount goes by a leaky piston, it escapes without doing effective work. Consequently, the turbine slows down and the pilot valve opens more and more until a large amount of oil rushes into the cylinder and pushes the piston so far at one time as to cause the machine to quickly speed up. Then, of course, the governor acts and shuts the valves, when the cycle begins all over again.

To correct this condition, take out the piston and put in shims that fit well into the piston-ring grooves. These will force the rings against the cylinder wall, preventing leakage around the piston. It may happen that when, for some reason, the load is suddenly dropped, the turbine starts to race. One cause may be that one or more valve rods are sticking in their stuffing-boxes and do not close, despite good working on the part of the governor.

Another cause, which is not so frequent, is that of worn and rusted or hard-working connecting-rods. The writer has been in a plant where for more than three years the 3000-kw. turbines have been working satisfactorily. It has been found lately, after a shutdown, that after dropping its load one of these machines races badly. It was found that there were two valves that did not close. The transmission bearing of the governor was worn, and the rod connecting with the pilot valve could not be pulled high enough to close all the valves. These turbines are running in parallel with hydro-electric stations, and before being thrown in on the line, the admission valve is opened only enough to maintain the synchronizing speed. Therefore the trouble was observed only when the machine was relieved of its load. These troubles are the most frequent that may happen to the governing system.

The emergency governor should be tested at least once each week, provided the machines are not in continuous operation for periods longer than that.

Emergency Governor Should Be Tested

When cleaning, and with the turbine out of service, the emergency governor should be moved by means of a rod or hardwood stick to ascertain that it works freely. See that its parts are carefully tested. There is little danger with parallel running turbines, where the dropping of load does not affect several machines. The racing of one turbine does not raise the speed of the others so quickly as it would with only one in service. Always test the emergency governor at the beginning and end of a long run. Usually, there is more time for the necessary governor verifications after the shutdown than at the time of starting. It is not always a tight spring that prevents the governor tripping at the predetermined speed. Rusted or dirty sliding surfaces, or some missing screw or small balancing weight may interfere with the normal operation.

Failure of Step Bearing Oil Pressure

There is a question that bothers many operators of vertical turbines, namely: What if the step-bearing oil pressure fails? Nothing serious would ordinarily happen to the turbine. In nine years the writer has seen this happen but once, and then failure was caused by the mistake of a man and not because of fault to be found with the machine. Shutting down the machine and leaving it excited will stop it in a short time. The step-bearing plates will be cut and the surface cracked, perhaps, by the heat produced. With a good oil-pressure accumulator there will be little trouble if the oil pressure should fail for the guide bearings having no weight to carry, will remain untouched. There are several European plants having air chambers as pressure accumulators. For their dimensions they are far better than the weighted accumulator so widely used in this country. A chamber 10 x 3 ft. will supply oil at 800 lb. for a 3000- to 5000-kw. turbine for from 12 to 15 min. With a tight air chamber there is not much leakage.

Throwing of the oil is troublesome and may be caused chiefly by leaky joints or by currents of air produced by the rotating parts. Deflectors placed inside or outside of the oil pans will help eliminate the trouble. Supplying too much oil is a common source of this trouble, especially where forced lubrication is so widely used as at present and where bearings have too much clearance. Then the oil may flow out along the shaft and be thrown into the alternator. The oil pans should be cleaned frequently, as the solid matter carried with the oil will obstruct the passages and the return piping in the pan will not be cleared of oil quickly enough to prevent the accumulated oil in the pan being sucked out under the deflectors. Should oil leak through porous castings, a mixture of litharge and glycerin applied near the points of leakage will stop the trouble.

Bearing Oil on Collector Rings

Special care must be taken where the collector rings are located under the upper bearings. Sparking and rapid wear of the brushes and cutting of the collector rings will show the presence of oil that should not be allowed to get there.

Vibration will invariably interfere with the good operation of a turbine. One of the most common causes is that the rotating part is out of balance. In this case weights must be applied to the light points of the rotor. These points must be located by patient and careful searching.

Balancing is in fact such a tedious job and one requiring so much skill that space here does not permit of adequately treating of it.

Effects of Electrical Unbalance

A bad electrical balance may be caused by short-circuited or grounded rotor windings. In this case the mechanical balance is good, and the vibration starts when the rotor is excited. By measuring the insulation and the resistance of the windings, the bad spots may be located. A rotor loose on its shaft, or wheels comprising the rotor loose on their shaft, will of course throw the turbine considerably out of balance. Incorrect blade clearances may cause vibration with increasing load. The shaft becomes heated more and more, carries the buckets against the intermediate or against the diaphragm nozzles, provoking vibration. I know of a case where a cracked diaphragm dropped down on the back of a wheel with the increasing pressure, and it worked as a brake on the turbine, with wrecking effect. When cold, there was nothing that would indicate the trouble, and it was a hard job to find its origin. A turbine that hangs, that is, one that does not set level, will usually vibrate with increasing load. If the condenser is not well supported by its bases, it may cause sufficient distortion of the turbine casing to produce vibration. Defective synchronizing may shake up the rotor so badly as to throw it out of balance, and may even bend the shaft.

A man staying with a machine for years knows it better than any outsider, even including its constructor, can possibly know it. Try to find out the strong and the weak points of the turbine in your charge, and do not be ashamed or afraid to take advice, especially of the experienced erecting engineers, who are usually glad to help an operator.

Clearing Chain-Grate Wind Boxes

By Edward T. Binns

In the furnaces of a 300-hp. boiler, the shutter boxes that ran diagonal to the chain travel were equipped with hand control for the distribution of the forced draft. The shutter boxes were only tributaries to the main wind duct.

The boilers were set in pairs and only about 4 ft. between the batteries, so that the clean-outs were inaccessible with hoes and scrapers. The fine ash and coal dust that sifted through the top chain gave considerable trouble and seriously interfered with the draft distribution.

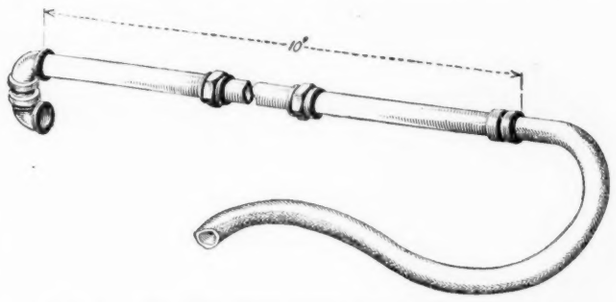


FIG. 1. JOINTED PIPE USED IN CLOSE QUARTERS

The clean-out doors were comparatively small, while the area around the wind boxes represented considerable space—virtually from wall to wall of the furnace and the entire area within the chain. The importance of clearing this space and the difficulty of the job seemed quite formidable. The illustrations show the plan that proved to be the solution.

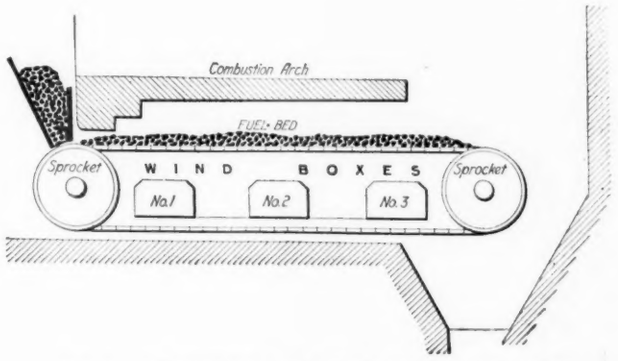
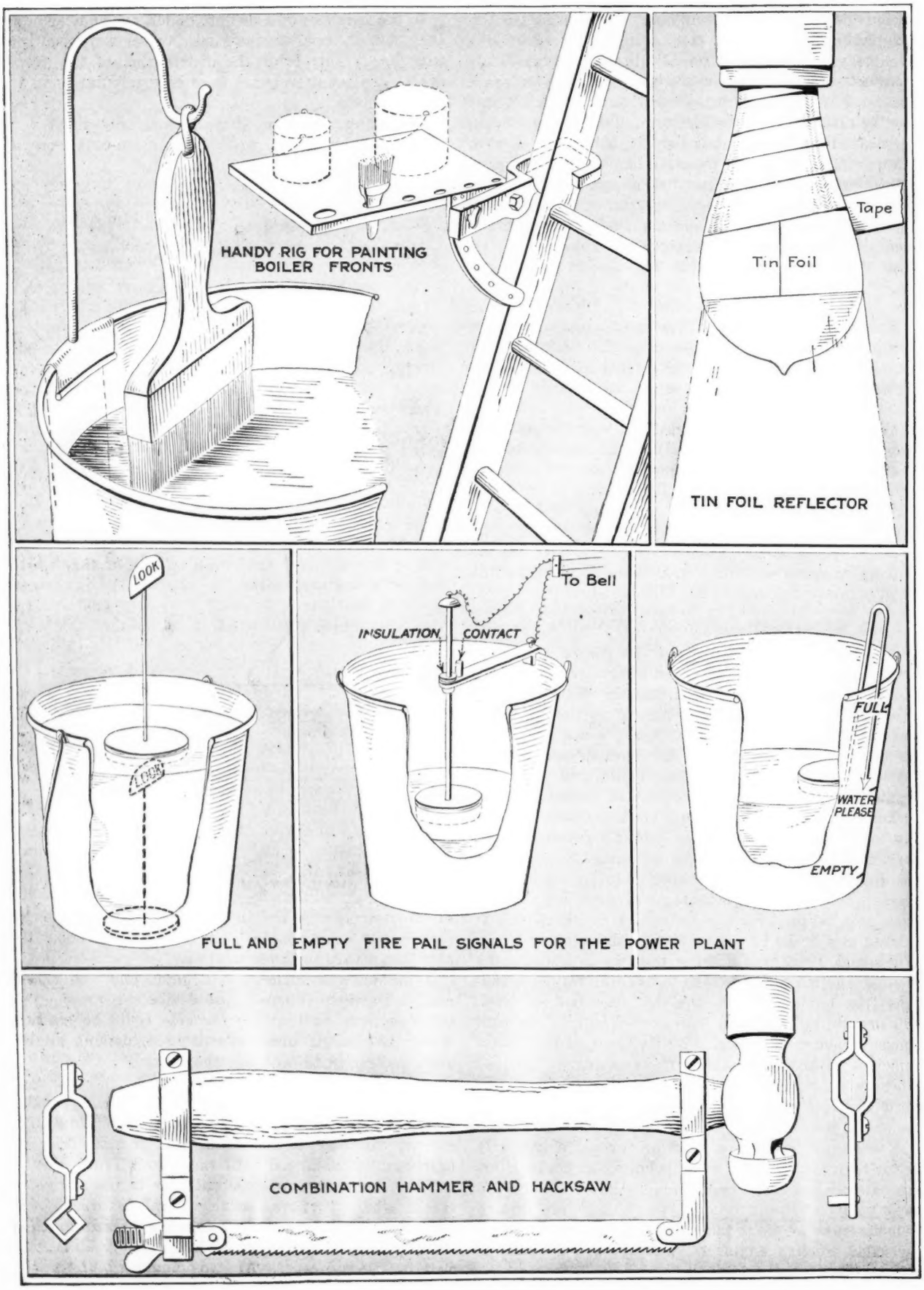


FIG. 3. AUXILIARY AIR DUCTS TO BE CLEANED

A blower was made of ½-in. pipe, and two elbows made a complete U-bend. The device was made up in three sections, so that the far side could be reached. About 100 lb. air pressure was used, driving all the deposit directly toward the operator.

A striking example of what is being done by our Canadian neighbors to help win the war appears in a current exchange to the effect that the Minister of Railways has arranged with the Grand Trunk Pacific and the Canadian Northern railroads to use the same tracks where they run nearly parallel through the Yellowhead Pass (Alberta) and has taken up over two hundred miles of the other line and shipped it complete for use in France. Are we doing our bit?

Some Handy Kinks



Editorials

Should the Government Promote Engineering Education?

MUCH is heard nowadays concerning the education of the engineer. Some go so far as to urge that as a matter of public policy all engineers should be qualified for service at public expense, such as is done by the state and Federal governments to foster agriculture. Millions of dollars are appropriated annually for this purpose. Bulletins and circulars of information are written by experts in simple, plain English and distributed throughout the length and breadth of the land free of all cost to farmers and stockraisers. Government agents are stationed in many communities to counsel and advise concerning farm problems. Never-ending experimentation is carried on in the hope of discovering new or improved methods and products for the farmer, the results of which are made available to him without money or price. The Federal Congress and state legislatures justify these vast expenditures on the ground that the farmer is too vital a factor in national life and prosperity to be allowed to shift for himself and to deal by rule of thumb and a limited personal experience with the intricate scientific problems involved in provisioning a nation.

Here is a precedent, it is argued, if precedent be needed, for government aid and coöperation in engineering education and practice. Like the farmer, the engineer is an indispensable factor in the well-being of the nation. He has to deal not with whim and fancy, but with the forces and elements of nature. At bottom his problems involve the utilization and conservation of the natural resources of the nation—the patrimony as it were of nature to man. With progress social life becomes increasingly complex. With division of labor comes the efficiency and expertness of the specialist, but also the interdependence of individuals and communities. Only the uncivilized who live upon the gifts of nature are today self-sufficient and independent as regards the necessities of existence. A large city, on the other hand, is always within hailing distance of starvation. The engineer is a product of this interdependent life, and his sway has increased as civilization has grown in complexity. His function has become so specialized that it cannot be dispensed with and none can substitute in his place. Light, heat, power, sanitation, irrigation, construction, intercommunication—these are vital elements in modern progress. They touch individual and community life at many points.

The education of the engineer, like the education of the farmer, is thus a problem of national concern. By some means or other the highest engineering skill must be available to government and industry. On this point no two opinions obtain. But whether state or nation should assume larger responsibility than at present for the supply and direction of this skill is a question on which sentiment at present is hopelessly divergent.

Developing the Water Powers

IN THE development of a water power controlled by the Government (that is, still owned by the people) there are four parties to be considered:

1. The people who control the privilege.
2. The capitalist who risks his money in its development.
3. The promoter who wants to make a paying business of the enterprise.
4. The ultimate consumer of the power generated.

The first class includes the fourth, and there is little, if any, conflict of interest between them. It may be urged that the first class, the whole people, is surrendering a privilege for the benefit of the restricted fourth class and should receive some remuneration for it, as by a charge which will, by the third party, be added to the price of the power and passed on to the fourth. But the benefits arising from the development of a great national asset, like the water powers, are not confined to the people in their immediate vicinity nor to the immediate users of the power which they supply. The diminution in the demand for coal should be a benefit not only to every user of fuel, but to every user of everything in the production, manufacture, transportation and distribution of which fuel is employed. A source of cheap power would be an advantage not only to the small users of electricity, but to industries in the vicinity of the development, and should act to the general benefit in a reduction of the cost of their products. Such an asset might also be of universal benefit when, under a possible condition of stress, we were obliged to take account of our resources as a nation and measure our capacity to do big things quickly and efficiently against that of an opponent.

The second party is presumably looking for an investment for idle capital. He may be identical with the third party, and he may not. He will need to be convinced that a particular water power is worth developing, and to be assured that the third party has the ability to make a success of the enterprise, and confidence, backed by a lien upon the things for which his money is to be spent, that he will ultimately get it back and will receive an acceptable rate of interest while it is in use. His only concern with the terms upon which the privilege is granted by the first to the third party need be that under those terms the Government cannot put his investment into jeopardy by confiscation of the property or by so embarrassing the third party that he cannot keep the enterprise so alive and profitable as to be a good security, return his money eventually and pay the interest on it in the meantime.

The first party has unlimited borrowing power and can develop the water power himself and furnish its output to the fourth party (which is largely identical with himself) at cost; but for lack of self-confidence or from a disinclination to go into business for himself,

he would prefer to let the third party do it for him if that third party will do it upon reasonable terms.

What should the third party expect? He should be able to get out of the business, over and above its legitimate expenses—which expenses will include salaries for himself and his associates in conducting it—enough to reimburse him, and through him the capitalist, for the money which he has invested, so fast as the plant for which he has invested it is used up or depreciates, and a fair return upon the amount of business which he can do. The first is depreciation, the second profit. The depreciation should be credited to the capital account, for it is in effect capital retired, and the profit should be based upon the volume of business done and the cost; that is, the selling price should be the cost plus a fair profit. If the money charged to depreciation is reinvested in renewals, extensions, etc., it should be recharged to the capital account. The depreciation should be as nearly as can be estimated the average annual used-up-itiveness of the plant, so that at the end of a time during which the plant may be safely estimated to continue serviceable, its full cost will have been collected. If something comes along before the machinery installed is used up that is so much better that it will not pay to run the old any longer, the capital account must be charged with the cost of the new apparatus less the scrap value of the old, and the increased efficiency of the new must be sufficient to take care of the depreciation and interest on this increase, or the change is not warranted. This is all there is to obsolesence.

The privilege should be granted with the stipulation that the power shall be sold at equitable rates as between different classes of users and at such prices that the aggregate profit shall not exceed a stipulated percentage of the total cost of production. If the promoter overcharges for depreciation, it will react in diminished allowable profit, through the lessening of the capital account upon which interest is charged, which interest is one of the items of the cost which determines the selling price. Besides, the Government should reserve the right to revoke the privilege and take the plant over at any time upon returning to the third party all that he has spent upon it, with such accrued interest and allowable profits as have not been already collected, and less what depreciation has been charged off. If too much depreciation is charged, the early customers will pay a large rate, but the Government will be in a position to take over the plant at less than its real value, or eventually for nothing, while it is still in serviceable condition.

A grant based upon these fundamentals would offer to the capitalist as much security as he would have in furnishing his money for the development of any similar privately owned stream. The Government cannot "recapture" it without assuming the promoter's obligations to him and practically converting his securities into government bonds. The extent to which the Government can interfere with the promoter's management of the enterprise is prescribed in the limitation of rates to cost plus a stated profit, and such oversight of expenditures as shall guard against unnecessary cost and insure that all the charges shall be fairly represented in property in sight or service rendered. The possibility of loading upon such a plant extensive tying-up charges with other systems not subject to recapture should also be considered.

To the promoter it offers full freedom to develop the possibilities of the project, to charge, while building up the business, rates that will pay a profit upon the disproportionate initial cost, to continue these rates until his average profit for the time the plant has been in operation shall equal the stipulated amount, and requiring adjustment with the establishment, growth and development of the business only to the extent that shall leave him an average profit for the time of his activity, of the percentage agreed upon. He is encouraged to build up a big business, for his profits are proportional to its volume, and to discharge his debt to his capitalist as fast as it can be fairly collected from his customers. And so long as he furnishes acceptable service at its cost to him, plus a fair profit, there will be no inducement or disposition on the part of the Government to revoke his privilege of doing so.

The consumer is assured of a supply of power at reasonable rates and is interested to extend the service and make it as successful as possible, for the greater the output the less the cost per unit and to him.

And the Government will have encouraged and provided for the development of one of its assets, with the consequent benefit to the people as a whole, in such a way that if at any time the privilege is misused or if, with all the changes that the future may bring, the interests of the people may at any time demand it, the use of that asset may be recovered without loss or wrong to those who have profited by it in the meantime.

True, there is no opportunity in such an arrangement for excessive commissions, stock or otherwise, to the financier, for a huge "unearned increment," nor for the selling back to the Government at the end of a fifty years' period a lot of intangibles at a "fair valuation"; but it does offer a safe investment to the capitalist at a fair rate of interest and a safe, fair profit to the promoter for his activities.

Is it for more than these that capital and industry are holding back?

If not, it is simply a question of agreeing upon such terms of interest and of profit as will induce the capitalist to invest and the promoter to develop; and these ought to be set by the difference which the people are willing to pay between the cost of having the power developed for them and of doing it for themselves.

While we are cognizant of the present coal situation, the volume of dense black smoke that rolls from chimneys in view from our desk reminds us that New York, great metropolitan New York, does not specify, regulate, approve or inspect boiler furnaces, and this in view of the ever-increasing use of soft coal in the city. It would some day be worth millions to the city if now, while the atmosphere is agreeably clear, the city government would enforce, with good engineering talent, the above control.

Loose wheels seem to have been a popular sport among turbines during the last year. Well, closer cooperation between designer, builder and user will produce better fits all round in the field where, after all, the turbine has got to live its life—and the operator live with it.

Correspondence

Experiences As an Erecting Engineer

I was erecting a new 1000-hp. air compressor, and as the starting of the plant was to be made an event of importance, it had to be rushed to be ready by the date set. When about to connect the steam main to the compressor, the local outside foreman ran a line from the bottom of the steam main, supplying the 5000-ton concentrating-mill engines, to the compressor. As this new main was "dead level" from the bend below the main to the bend leading to the cylinder and the steam was very wet in an uncovered pipe, it made an ideal trap for water with 120 lb. steam on it. I vigorously protested against it but, being a stranger, was overruled.

Expecting some trouble, I started to carefully open the drain pipe leading to the steam jackets on the engine. No sooner was the valve off the seat than "Bang, crack, bang!" came the answer. I closed the valve and watched to see what would give way first, for the pipe shivered, the cylinder rocked, then a gasket blew out of a joint at the end of the pipe and relieved the water in a deluge. Most of the men ran out as soon as the trouble started, and as the water passed overhead no one was injured. Orders were issued that the drain pipe was not to be shut while that steam connection was in use.

In the same plant we were to put in a new 12-in. steam main, and to make permanent joints the chief engineer ordered them made of one strand of copper wire between the flanges. I was in charge of about one hundred feet of outside pipe, and the foreman took charge over the boilers. Expecting that one wire close in to the bore would strain the flange, I used two concentric wires, one close to the bore and the other one close to the bolts, and for this reason we broke no flanges.

The foreman used only one wire on his section, and when the bolts were drawn up, they cracked nearly every flange. As things were not safe to run, I called the manager's attention to the flanges and deliberately broke the worst specimen with a hammer to show him what would happen; but the foreman, who belonged to the old school, was very angry because I refused to be responsible for what might follow if we put 120 lb. pressure on the line.

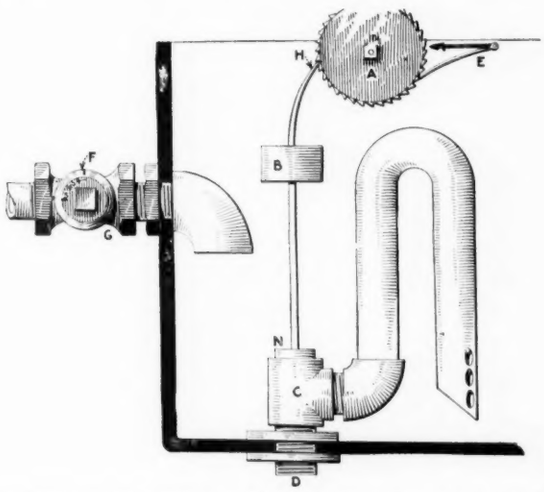
Some time after I left they had the compressor off for repairs and adjustments, and when ready to start, the fitter sent his laborer to open the 8-in. gate valve on the air main; but with 80-lb. gage pressure on one side of the valve he could not move it, so reported that the valve was open. They started the compressor and blew the top off the high-pressure cylinder, and one piece weighing nearly 150 lb. landed about 400 ft. away after passing just over the fitter's head and through the wall of the building. The plant was fully equipped with all the necessary gages, etc., but neither the fitter, the driver nor the foreman had watched them. And yet we wonder why there are so many serious accidents. Fortunately, no one was killed, but some were thoroughly scared. The fitter had stooped down to close a drain valve, and that is why his head was saved; the other four men were on the opposite side of the room from where the pieces flew, so their luck was also in.

H. N. PAIGE.

Queenstown, Tasmania, Australia.

A Measuring and Tally Tank

A tank made as described will give a close record of the quantity of water used in a given time, is useful in small plants and is easily made. An ordinary 1½-in. siphon *C*, such as is used in closet tanks, is placed in a tank of any desired size. *N* is a flap valve which is raised by float *B* to start the siphon when the water has reached a certain level. *H* is a piece of flexible steel (a piece of clock spring will answer) fastened to the



CONSTRUCTION OF A MEASURING TANK AND TALLY

float. The top end is used to force the toothed disk *A* around the distance of one tooth each time the float rises. The float must of course be suitably guided to hold the spring against the tooth.

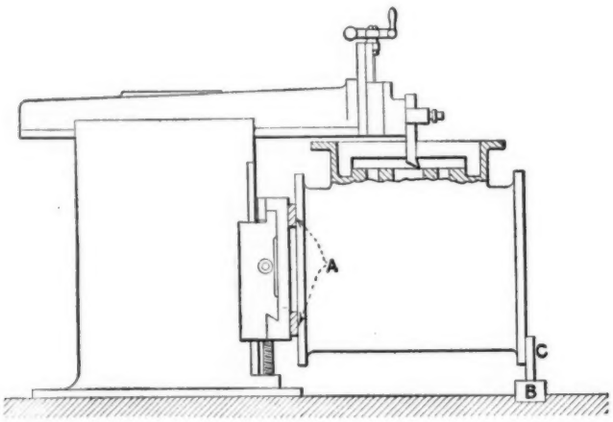
The disk may be made of sheet iron or other metal and is fastened to the tank by a bolt or screw. *E* is an indicating hand and may also serve to keep the disk from turning backward. *G* is the water supply to the tank, and *D* is the discharge. One short mark *F* is made on the body of the plug-cock *G* and three or more on the top of the plug, as shown. When the measuring tank is put into use, the first thing to do is to find the amount of water that will pass at a "flush" with the plug-cock opened with each of the marks (1, 2 and 3) opposite mark *F* and make a note of the quantity in each case.

The siphon should be two sizes larger than the feed pipe, especially if there is a fairly high pressure on the supply pipe. Knowing the amount of water passed "per flush" with the plug-cock set at the different marks and the disk showing how many times the tank has filled and emptied, the rest is just a matter of multiplication.

Portsmouth, Ont., Canada. JAMES E. NOBLE.

Facing Valve Seat on a Shaper

I was once in charge of a sugar mill located several hundred miles from a machine shop, but we had several machine tools large enough to handle most of the work for the mill. The engineer before me had thrown out two steam cylinders for the dry-vacuum air pumps because of scored valve seats. New ones had been installed in their place, but they were not in much better condition than the old ones after they had been in service a short time. Our planer was too small to take the cylinder between the housing, so we decided to try



STEAM CYLINDER BOLTED TO SHAPER SLIDE REST

the job on the 16-in. shaper. The table was removed from the slide and two parallel pieces were bolted to the slide, as shown at *A*. The cylinder was then placed in position, leveled and clamped. To support the outer end of the cylinder a planed block *B* was set into the floor level with the shaper slide rail and another piece *C* was bolted to the cylinder and rested on *B*. This made a secure support, and the valve seat was finished up in good shape. E. S. RAY.

Arthur, Ill.

Rotor End Connections Loose

When a motor that apparently has been operating normally for many years is repaired, reconnected or otherwise modified and the machine appears to be unable to start after the changes have been made, it is fair to assume that the changes are in some way involved in the failure of the motor to start. That such a natural assumption may at times be unwarranted is proved by the following experience.

A heavy three-phase 220-volt squirrel-cage induction motor that had been operating on a 25-cycle circuit had to be changed for 600-volt 40-cycle operation. The circuits of the motor stator were reconnected from a two-circuit Y to a one-circuit Y; this reconnection increased the voltage rating from 220 to 440 volts, and the 60 per cent. increase in frequency was to account for the additional increase in the voltage rating. After the change in connections was made and the time came for trying out the motor, it could not be started, the operator claiming that the new connections were responsible for sparks jumping across from the stator winding to the rotor.

Investigation disclosed that the rotor end connections were sparking because they were loose. In trying several times to start the machine in order to see exactly what was happening, there occurred each time one or more light explosions similar to those that occur when small conductors are being electrically welded. It appeared that this was exactly what was taking place, because on the fourth attempt to start there was an explosion a little more decided than any of the preceding ones, and immediately after it occurred, the rotor promptly started and came up to speed. Apparently the heating incident to the heavy starting currents had expanded the rotor parts, bringing them together with so much pressure that the voltage generated in the bars when standing was sufficient to break down the resistance of the poor joint and weld it.

Brooklyn, N. Y. E. C. PARHAM.

Publicity About Turbine Troubles

I was greatly interested in the letters relative to publicity of turbine troubles; namely, that by Professor Trinks, and the answer to it by Mr. Low, editor of *Power*, both of which appear in your issue for Oct. 2, page 464.

It is high time that somebody complained about the keeping secret of engineering troubles that it is to the interest of the art that the profession should know. The letters undoubtedly touch a responsive chord, not only among teachers, students and operating engineers, but among mechanical engineers generally and even among those engineers in whose plants some of these accidents have happened.

It seems that it would be to the advantage of the builders of the turbines to permit of more publicity relative to accidents that have happened to their machines. With the vague rumors that seep through, the tendency is to create a much more serious impression than the real nature of the accident would cause if it were as widely known. Take, for example, the case of a machine in a Boston power station. All sorts of rumors were afloat relative to what had happened to this machine. It was claimed to have been all the way from merely a loose wheel on the shaft to the complete wreck of the rotor and much of the stator. As near as I can learn, it was merely a matter of a loose wheel on the shaft with the loss of some blades on one of the wheels.

The same may be said of the machine in a plant in western New York State. Here the machines are not of extraordinarily large size as turbine capacities go today, but the conditions of pressure and superheat are unusual. Trouble was experienced with the turbines in this plant, and rumor had it that one or two of the machines had been so badly damaged as to amount to a wreck. The most accurate information shows that the trouble was nothing more than a loose wheel on the shaft, occasioned by the extreme temperature difference to which the rotor was subjected. The high-

pressure wheel, together with the shaft at that point, is subjected to steam which is at a temperature of nearly 700 deg. F. At a point about five feet toward the low-pressure end along the rotor, the temperature is down to about 100 deg., giving a difference of practically 600 deg. As the wheels are shrunk on the shaft, the clearance must, for this extreme temperature change, be exceedingly small. These wheels, as far as I can learn, have been bushed and the clearance reduced considerably. This has eliminated all trouble due to loose wheels.

Trouble in Electrical End

All sorts of wild rumors are afloat about the recent trouble at the Essex Station of the Public Service Electric Co., Newark, N. J. Though one hears that loose wheels and lost blades and even worse happened there, the best information coming to the writer shows that the trouble was not in the steam ends of the two machines that "went out"; but that the causes were purely electrical. Here is another instance where most serious rumors have spread because the facts did not receive publicity through reliable channels.

Every engineer with his ear to the ground knows that serious turbine trouble has been reported from nearly all the large power stations throughout the country, especially during the last year and a half. I have watched the engineering magazines for descriptions and analyses of these accidents, but for the most part it may be said that no mention has been made of any of them. Inasmuch as in nearly all human affairs fear may properly be ascribed to ignorance, the keeping secret of the nature of these accidents has been of appreciable influence in causing the attitude of engineers toward the more modern turbines to be what it should not be.

Besides creating an unwarrantedly serious impression, keeping secret the nature of these accidents cannot fail to work harm through the profession generally. Professors in our technical schools and institutions, who are training men who some day will be turbine designers and station operators, find it practically impossible to learn enough about the details of accidents to turbines to instruct their classes intelligently in what these accidents mean as related to the design and to the strength of materials that go to make the machine.

Frank Discussion Minimizes Accidents

The value of open, frank and intelligent discussion of the design, construction and accidents to boilers has led to the development of pressure vessels that are, considering the conditions that they have to undergo in operation, surprisingly safe as contrasted with the pressure vessels of the past. There is no doubt that the same open and frank discussion would minimize accidents to turbines. Accidents to turbines in these days are to the higher-capacity machines and are of greater concern to the engineer than the turbine trouble itself may present as confined to the disabled machine. Upon the susceptibility of these large machines to accidents that put them out of commission for periods long or short, the station engineer is greatly interested in the problem of reserve capacity that he must install. These are days of continuous uninterrupted service. The public as customers not only demand it, but the state, through its commissions, is ever ready to conduct inquiries into the cause of service interruptions.

In these days of large-capacity units the question of reserve capacity is certainly vital enough, solely because of the large size of the individual units, to say nothing of making it considerably more severe because of the likelihood of accidents that may put too many of these machines out of service at one time in a particular plant.

Effect of High Pressures

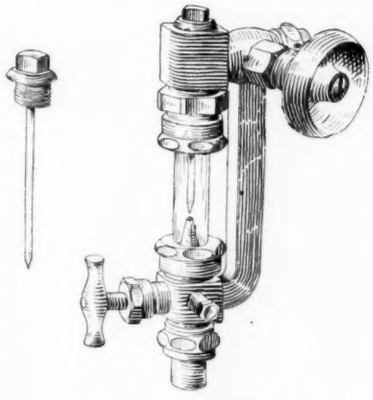
When high boiler pressures—up to 1000 lb.—were first talked of a few years ago, the average man claimed that it was merely a question of getting a boiler that would stand the higher pressure. In view of the troubles that have developed in turbines since we have gone from the high pressure of 200 lb. to nearly 300 lb. for the average modern station and to 350 lb. for some exceptional stations, and, further, because these troubles have been due chiefly to great temperature differences between points close together on the shaft, is it not logical to ask if the advance toward higher boiler pressures will not be thwarted and made slower by fear of what may happen to the turbine if subjected to still more extreme conditions of temperature and pressure?

Take the case of one purchaser. One or more large capacity, single rotor turbines were on order for his plant. Not long after the order had been given a turbine of the same type in another city was reported to have "gone to pieces." Naturally the man with such machines on order was interested, if not alarmed. His engineer was sent to the city where the "wrecked" machine was located. He could get no information, not even from the owners. This only made him the more apprehensive. He remained in town long enough to "steal" the facts. And what were they? A few loose blades on one or two wheels—a mechanical difficulty easily corrected by the builders.

New York City. H. Rhoades.

A Novel Lubricator Kink

A kink that has been adopted by one of our watch engineers to prevent the lubricator sight glasses from becoming fouled by oil adhering to the inside is shown in the illustration. A piece of slender brass wire is soldered to the plug at the top of the sight-glass column and is long enough so that the tapered point will reach nearly to the oil outlet tube in the bottom of the glass. The oil will feed up on the wire and not touch the inside of the glass. This saves many glasses, for most of them are broken when they are taken out for cleaning.

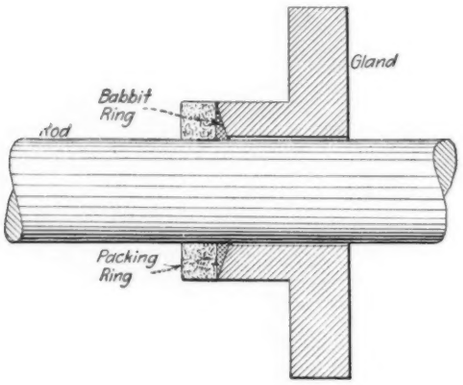


GUIDE WIRE IN LUBRICATOR

Concord, N. H. C. H. Willey.

Casting a Ring on Piston Rod

The piston rod on our engine had been turned down, leaving the gland a loose fit, and trouble was experienced in keeping the packing from blowing out. I remedied it by casting a babbitt ring on the rod.



BABBITT RING CAST ON THE ROD IN FRONT OF GLAND

First I wrapped the rod with heavy paper, then wedged the gland central with the rod, put a ring of packing on the rod to babbitt against and made the job leak-proof with clay. Only a little dressing up was required after the ring was cast, and it does the work satisfactorily.

H. VIPOND.

Killarney, Man., Canada.

Training of Operating Engineers

In reply to Mr. Dale's questions in the issue of Sept. 18, page 399, relative to our course (Williamson Free School of Mechanical Trades) in operative engineering, I may explain that all the work under the head of "Steam Power Plant Equipment" is covered by the one entry "In Shop" in the synopsis published in *Power* in the issue of July 17, page 95. The qualifications and ability possessed by our students when entering the commercial field are shown by the fact that we are unable to send out enough young engineers to supply the demand for their employment. These young men enter large operating companies as well as small plants, and according to the reports we receive they are successful in both branches of service and the cultural subjects appear to be beneficial to them. Comments on the part of employers are generally favorable.

One serious drawback of the short course is that it eliminates nearly everything except that which is absolutely necessary to the understanding of the technical subjects involved. This is intended in no way as a criticism of the short course, as it serves a useful purpose, but if it is possible to gain some cultural as well as technical training, one should be decidedly better and happier. Our course is three years, and we are able in that time to give boys between the ages of 16 and 21 a thorough grounding in the elements of operative engineering in addition to a fairly good education.

The outline by Mr. Dale impresses me as being very good for a two-year course, considering the type of men for whom it was intended. There is likely to be a difference of opinion relative to the details of any course, but I am sure the course laid out by Mr. Dale would prove of great value to any person employed as an operating engineer.

If Mr. Dale will send me his home address, I shall be pleased to send him one of our manuals used in connection with teaching operating engineering in the hope that he will agree after a survey of it that our course is a thoroughly practical one. In any event it proves very attractive to candidates for admission to our school.

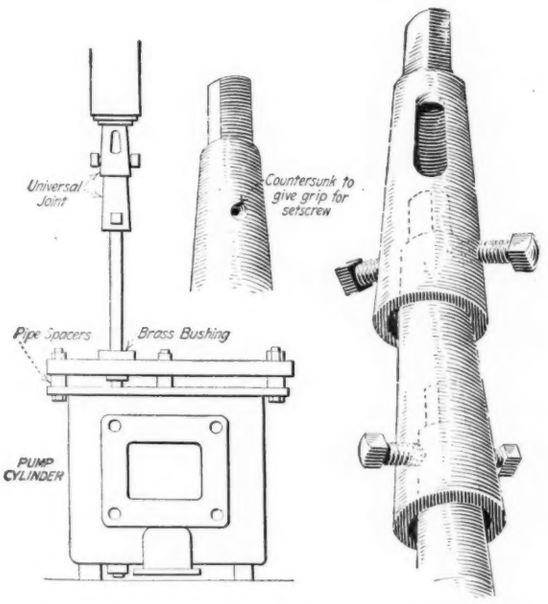
JAMES A. PRATT.

Williamson School P. O., Penn.

Reboring Pump Cylinder on a Drill Press

In our isolated plant the steam cylinders of a 7 x 10 water pump became badly scored, and the question arose how to make a quick repair with the comparatively small resources at our disposal. The double-cylinder casting was too big for our lathe, and a portable boring tool could not be had earlier than 12 days. Anyway, the owners would not go to such an expense for the comparatively small job.

The reboring was successfully done on a drill press, as shown in the illustration. A heavy cast-iron plate was securely fastened, with bolts through pipe spacers,



BORING BAR DRIVEN WITH DRILL PRESS

on the head end of the cylinder, and a bushing was fitted into the stuffing-box and centered, forming a neat sliding fit for the boring bar, which was driven by the drill-press spindle and the feed adjusted to suit the cut.

The two loose-fitting sockets driven by setscrews formed a universal 2-joint coupling. When one cylinder was done, the plate was reversed and the other one bored in the same way. The job took 19 hours, but with practically no expense for material, the only particularly difficult or tedious operation being the setting of the boring bar true, as it had to be centered from the counterbore.

LUDWIG V. LAUTHER.

West New York, N. J.

Inquiries of General Interest

Stopping Small Leaks in Tubes of Water-Tube Boilers—How can small leakage of tubes of a water tube be prevented without shutting down the boiler? T. L.

Small leaks usually can be stopped by mixing bran or cornstarch with the feed water. Leakage due to a split tube may be temporarily arrested in this manner, but with continued use the split will extend and permit leakage along a greater length of the tube.

Electricity from Escaping Steam—Is electricity generated by escape of steam at places where there is leakage in a low-pressure steam system, and is more electricity generated by escape of dry steam or of wet steam? G. W.

Undoubtedly, the discharge of steam at low pressure and low velocity through an orifice is accompanied by generation of electricity, although the potential of the discharge at low velocities usually is so low that the presence of the charge is difficult to detect. Faraday found that the generation of electricity from escaping jets of steam was solely due to the friction of globules of water against the sides of the orifice, but could detect no production of electricity when the steam was perfectly dry.

Equivalent Evaporation Under Changed Conditions—If a boiler evaporated 3500 lb. of water per hour from feed water at 100 deg. F. into steam at 125 lb. pressure, how many pounds would be an equivalent evaporation from feed water at 200 deg. F. into steam at 150 lb. pressure? A. S.

A pound of steam at the pressure of 125 lb. gage, or 140 lb. per sq.in. absolute, contains 1192.2 B.t.u. above 32 deg F., and when generated from feed water at 100 deg. F., or 100 — 32 = 68 deg. above 32 deg. F., each pound of feed water would receive 1192.2 — 68 = 1124.2 B.t.u. A pound of steam at the pressure of 150 lb. gage, or 165 lb. per sq.in. absolute, contains 1195 B.t.u. above 32 deg. F., and if generated from feed water at 200 deg. F., or 200 — 32 = 168 deg. above 32 deg. F., each pound of the feed water would have to receive 1195 — 168 = 1027 B.t.u.; hence evaporation of 3500 lb. of water from feed water at 100 deg. F. into steam at 125 lb. gage would be equivalent to evaporation of 3500 × 1124.2 ÷ 1027 = 3521 lb. of water from feed water at 200 deg. F. into steam at 150 lb. gage.

Allowable Pressure for Stayed Firebox—What working pressure would be allowed for the flat sides of a boiler firebox ⅝ in. thick, stayed with screw and riveted stays 1 in. diameter under the thread and pitched 5 in. by 5 in.? E. S.

The maximum allowable working pressure for the plate, pounds per square inch, would be given by the formula, $P = C \times t^2 \div p^2$, in which the value of C for ⅝-in. plate would be 112 and for stay-bolts pitched 5 in. by 5 in. the maximum allowable working pressure would be $112 \times 5^2 \div 5^2$, or 112 lb. per sq.in. With this working pressure, each stay-bolt would be called upon to sustain a load of (5 × 5) × 112 = 2800 lb. Having stay-bolts 1 in. diameter under the thread, the net cross-sectional area would be 0.7854 sq.in., and allowing a stress of 7500 lb. per sq.in. of cross-section, each stay would be capable of sustaining a load of 0.7854 × 7500 = 5890 lb., or more than twice the load that would be due to the working pressure allowable for the plate.

Construction of Blowoff Tanks—Of what material should a closed blowoff tank be constructed, and if it is provided with an open vent, is it necessary to have the tank strong enough to hold the pressure carried on the boiler from which blowoff is received? R. W.

Blowoff tanks are subjected to severe shocks from water-hammer that may cause stresses in the material much in excess of those from the pressure at which the boiler is blown off, even when the tank is provided with a large open vent. The material is also subjected to extraordinary stress from unequal expansion due to sudden changes of temperature that may eventually result in rupture without warning. Hence cast iron is an unsuitable material for blowoff tanks, and many serious accidents have occurred from failure of blowoff tanks made of that material, and in cases where the tanks were assumed to be adequately vented. A blowoff tank should be made of heavy steel or iron plate in best boiler construction and, as a closed tank, should be capable of safely withstanding not less than two to three times the working pressure of the boiler to which it is connected.

Hoop Stress in Water-Leg of Vertical Boiler—In a vertical fire-tube boiler 52 in. diameter with firebox 48 in. diameter, and carrying 80 lb. pressure, what would be the hoop stress per inch length of the longtiudinal joint of the portion of the shell surrounding the water-leg? F. C.

Assuming that the firebox stay-bolts render no assistance to the outer shell, the hoop stress per inch of length of the longitudinal joint would be the same as for a cylindrical shell 52 in. in diameter; namely, (52 × 80) ÷ 2 = 2080 lb. But if the boiler is provided with radial firebox stay-bolts that are properly spaced for staying the outer shell as a flat surface, and are of sufficient strength to transmit the load on the firebox sheet to the outer shell, the latter will be relieved of that much bursting pressure. In case of a firebox 48 in. diameter, an outer shell 52 in. diameter and boiler pressure 80 lb. per sq.in., the outer shell would be required to sustain a hoop stress of (52 — 48) × 80 ÷ 2 = 160 lb. per inch length of longitudinal joint. But from the uncertain efficiency of the stay-bolts they should not be depended upon relieving more than about one-half of the initial hoop stress.

Steam Delivered by 2-In. Pipe Line—What quantity of steam at 140 lb. gage would be delivered per 24 hours to a customer through a 2-in. pipe line 200 ft. long? T. D. B.

The size and length of the supply pipe cannot be taken as a basis for estimating the quantity of steam drawn without knowing the pressure maintained in the delivery end of the pipe. The formula for the flow of steam in pipes is

$$W = 87\sqrt{\frac{w(p_1 - p_2)d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

where

W = Weight of steam flowing; lb. per min.;
w = Mean density or mean weight per cubic foot of steam in the pipe;
p_1 = Pressure in lb. per sq.in. at the entrance;
p_2 = Pressure in lb. per sq.in. at the exit;
d = Diameter of pipe in inches;
L = Length of pipe in feet.

In the example, if it is assumed that the pressure at the exit end is 130 lb. gage, then as the density of steam at 140 lb. gage is 0.3425 and the density at 130 lb. gage is 0.3213, the value of W to be used in the formula would be (0.3425 + 0.3213) ÷ 2 = 0.3319, and by substituting this and the given values of p_1, p_2, d and L, the formula becomes,

$$W = 87\sqrt{\frac{0.3319(140 - 130) \times 2^5}{200\left(1 + \frac{3.6}{2}\right)}} = 37.85 \textit{ lb. per min.}$$

and flowing under the conditions assumed, the discharge would amount to 37.85 × 60 × 24 = 54,504 lb. of steam per 24 hours.

Peculiarities of An Engine Wreck

A 325-hp. tandem-compound engine is wrecked. Three causes are possible—water, failure of the crosshead or the fracturing of the distance piece between the cylinders. An analysis of each possible cause is given, showing what might be expected to occur under each.

AN interesting accident, from an engineering point of view, occurred Wednesday afternoon, Oct. 10, when a 325-hp. tandem-compound engine, Fig. 1, was wrecked at the plant of the A. I. Root Co., Medina, Ohio. An examination of the engine showed that the crosshead was

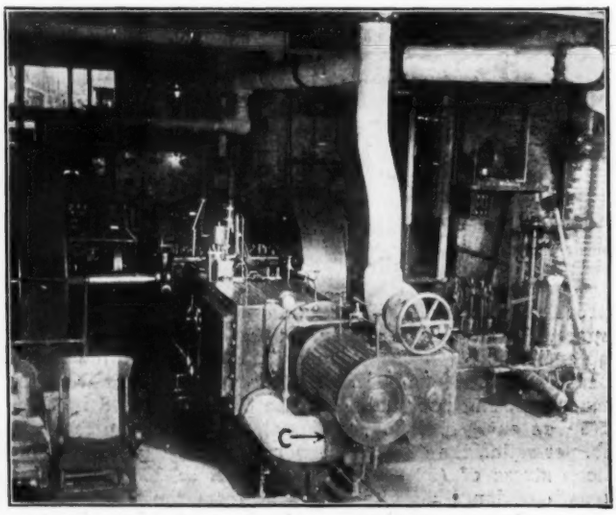


FIG. 1. TANDEM-COMPOUND ENGINE, SHOWING CYLINDER-PIPE CONNECTION

badly smashed, the distance piece between the high- and the low-pressure cylinders was broken into about a dozen pieces, the crank was bent into an ogee bend and the bolts were sheared on the pipe connection between the high-pressure cylinder exhaust and the low-pressure cylinder, at the high-pressure end. The hollow high-pressure piston showed a triangular crack from the three plugs, due to an external force brought against it. The bolts holding the crosshead guides in place were also sheared. According to the engineer the engine, which was a Skinner tandem-compound with cylinders 15 and 25 x 20 in., was operating at the time of the accident with a normal full load at 200 r.p.m. and with 150 lb. pressure, the admission to the low-pressure cylinder being about 35 lb. The engine, which was installed less than four years ago, was running smoothly with no indication of anything wrong just prior to the wreck. There are three causes to which the accident can be attributed—to water, to the failure of the crosshead or to the cracking of the distance piece between the two cylinders; the crank-end high-pressure cylinder head and the head-end low-pressure cylinder head were made in one casting with the distance piece.

An analysis of these three possible causes of the wreck is of interest. Taking up that of water, the following facts are pertinent. Steam from the boilers was piped to the

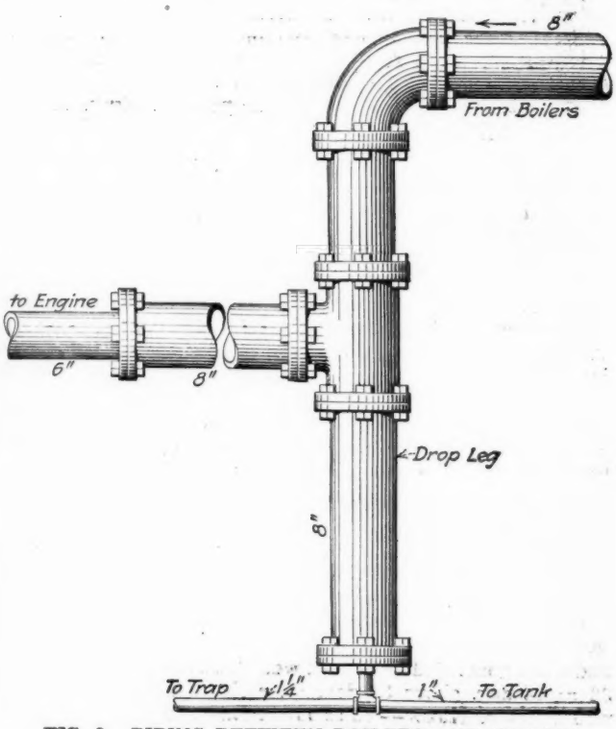


FIG. 2. PIPING BETWEEN BOILERS AND ENGINE SHOWING DROP LEG

engine room through an 8-in. pipe line. Just inside of the engine room this pipe line dropped and terminated in a tee and an 8-in. drop leg. From the tee a pipe ran hori-

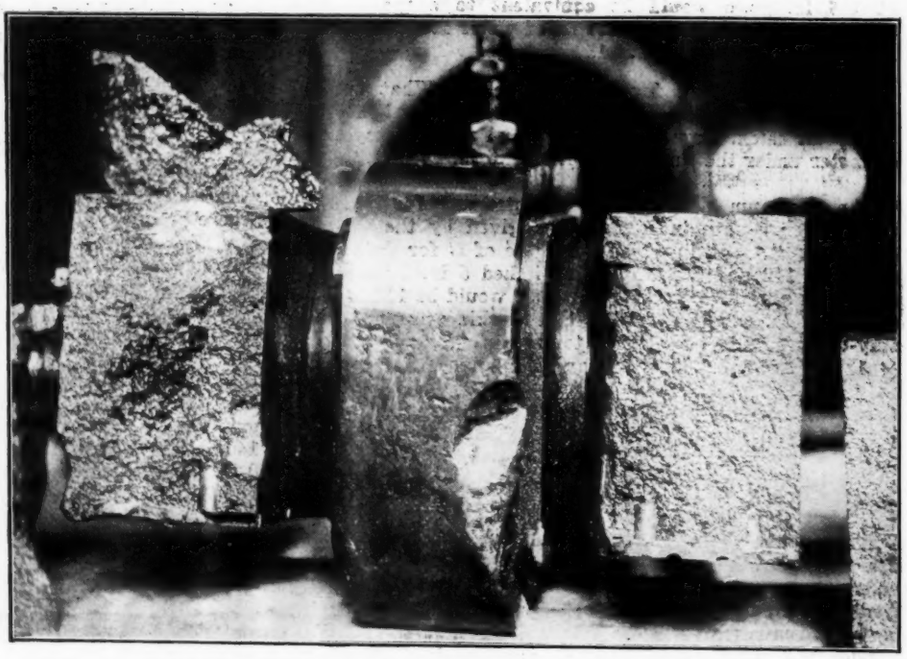


FIG. 3. BROKEN CROSSHEAD. DARK PORTION AT LEFT SHOWS POOR METAL

zontally to the engine, being reduced to 6 in. about midway between the engine and the tee. From the bottom of the drop leg a 1¼-in. pipe extended down to a tee, one side of which was piped to a trap; to the other tee outlet a 1-in. pipe ran to a heating tank in the yard, Fig. 2.

That the drop leg was not full of water at the time of the accident, owing to a possible failure of the trap to operate, is proved by the fact that the man who was working at the heating tank reported to the boiler room, immediately after the steam had been shut off from above the boilers, that someone had shut off his steam supply to the tank. This, together with the fact that a steam trap was connected to the drop leg, would indicate conclusively that the drop leg was thoroughly drained at the time.

That a slug of water came over from the boilers is not probable, as the water was but a trifle above the center water-column gage-cock. However, assuming that water did go over to the high-pressure cylinder, there should have been some trace. The water used in the boilers contains considerable mud. If the boilers had been foaming, the possible slug of water would have contained mud and it would have shown in the high-pressure cylinder and in the relief valves with which it was fitted. Neither the cylinder nor relief valves showed signs of mud or other deposit. Furthermore, if a slug of water had come over to the engine, some of it would have been forced out of the relief valves and onto the floor. There was no evidence that this had occurred. From the foregoing it is evident that water had no part in the accident.

A second possible cause of the accident is the breaking of the cast-steel crosshead. That it was weak is indicated by the character of the metal in the left side, as shown in Fig. 3 by the dark area. This is also shown in the small piece of metal on top of the crosshead. The metal at this part of the crosshead contained numerous large blow-holes and the metal had the appearance of slag in texture; in other words, it was honeycombed. The crosshead, which was of the old locomotive type, fractured at the yoke end on both sides, and the nipple in which the piston rod screwed was broken in halves. The side of the crosshead containing the poor metal was pulverized into small pieces, which would indicate that the tensile strength at that point was low. An examination of Fig. 6 shows the condition of the distance piece between the two cylinders after the accident. The edge shown at *A* represents the broken metal that has been forced out of the flange, which, with one exception, was left bolted to the low-pressure cylinder. The break *B* at the other end of the distance piece extends through the casting as does the one on the bottom side of the casting, which is about opposite that at the top but does not show.

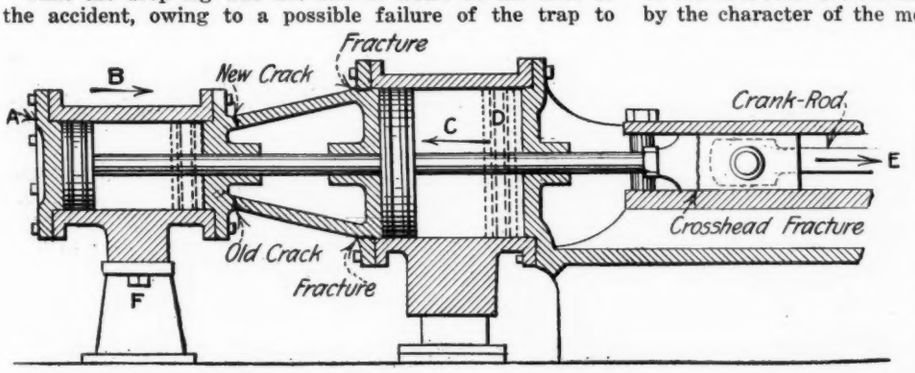


FIG. 4. SECTIONAL DRAWING OF THE CYLINDERS, SHOWING THE DIRECTION OF FORCES TENDING TO FRACTURE THE VARIOUS PARTS

A—High-pressure head uninjured. B—Direction of pulling force from crosshead with the piston against the head to cause concaved piston. C—Direction of force if the crosshead broke first. D—This piston would not touch the head with the high-pressure piston against its head after the cylinder had moved away from the distance piece. E—Direction of pull to break the crosshead. F—Sheared bolts allowed the cylinder to move toward the head end after the distance piece had broken

FIG. 5. HIGH-PRESSURE PISTON, SHOWING TRIANGULAR CRACKS AND BROKEN RIM

FIG. 6. FRACTURED CYLINDER DISTANCE PIECE

If the crosshead failed first, the condition at *A* would be just what might be expected. With the pistons at the crank-end and steam admitted to that end of the cylinder, the piston would have the effect of a hammer moving through a space of 20 in. with an initial pressure behind it of 35 lb. per sq.in. The impact of the piston against the head-end head of the low-pressure cylinder would tend to punch the area of the head entering into the cylinder out through the flange at the points marked "Fracture," Fig. 4. This is just what happened. If, however, the crosshead broke first and fractured the low-pressure head, as shown, it would seem that the high-pressure piston would have knocked out the head-end cylinder head on the high-pressure cylinder. As a matter of fact, this head was not even cracked and shows but one mark, which was doubtless made by a piece that is broken out of the high-pressure piston, Fig. 5. The high-pressure cylinder was found to have moved away from the low-pressure cylinder sufficiently to shear the bolts at *C*, Fig. 1, on the steam connection between it and the low-pressure cylinder. This may have been due to the force of the blow delivered by the low-pressure cylinder against the head. This blow would also account for the fractures *D* in the distance piece, as shown in Fig. 8. The fact that the center area surrounding the piston contains several cracks, which are opened up as from a blow delivered at the center from the crank sides, also leans toward the theory that the crosshead broke first, the open cracks being caused by the nut on the piston rod striking the head before the piston reached it. That the crank rod is bent S-wise does not enter into the problem, as it was doubtless caused by a piece of the crosshead getting between the end of the rod and some part of the engine after the crosshead broke, as indicated by the dent on the rod, Fig. 3.

From the foregoing it would appear that the crosshead broke first and that the steam pressure exerted against the low-pressure piston forced it against the head, fracturing the distance piece.

Dropping this line of reasoning, another set of conditions exist which appear to upset the theory that a broken crosshead caused the wreck. Examination of the distance piece disclosed that a crack on the bottom side had existed for some time, the surface of the metal being discolored by oil and grease. This crack extended through the rib, as shown by the dark portion *E*, Fig. 8. The only explanation to account for its presence is that some months ago water came over into the cylinders and two or three thumps were the result. It is reasonable to assume that the initial crack in the distance piece occurred at that time. If the distance piece between the cylinders had fractured before the crosshead, the results made manifest would have resulted. With steam at 150 lb. pressure admitted to the head end of the high-pressure cylinder, the tendency would be for that cylinder to move away from the low-pressure cylinder. With sufficient movement in that direction the high-pressure piston would then strike the crank-end head, which it did, as is indicated by Fig. 5, where cracks are shown extending from the plugs on the head-end side of the piston. The area inside these cracks is drawn toward the center of the piston. It is not evident that the force of the piston striking the head was responsible for this. It appears, however, that with the cylinder moved away from the low-pressure cylinder sufficiently to shear the base bolts, the piston came against this head and with the piston not quite at its full stroke caused the crosshead to pull apart as the crank passed the dead-center. This would exert a pulling force and concave the piston.

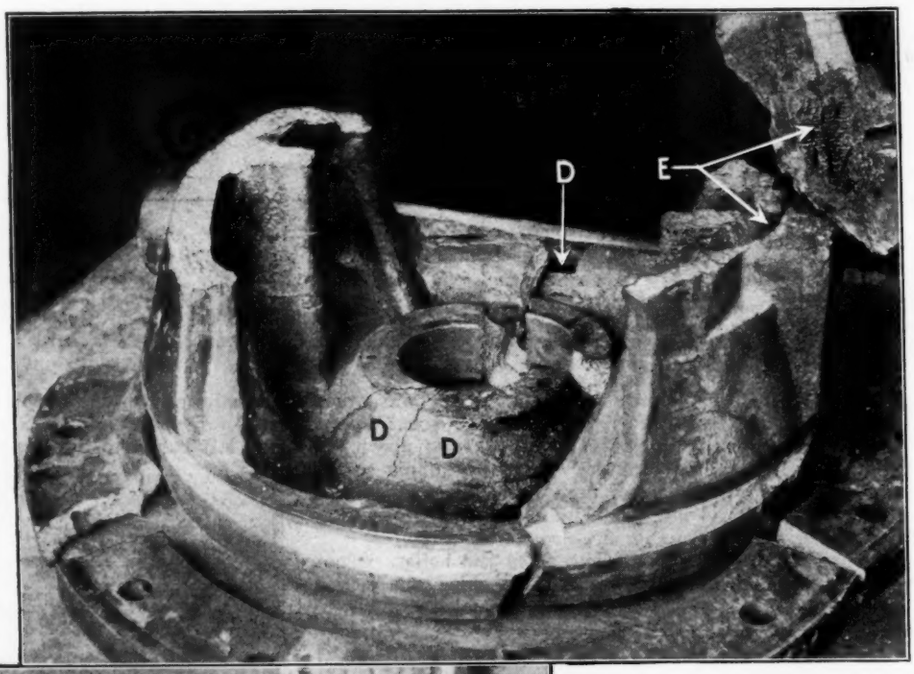


FIG. 8. BROKEN DISTANCE PIECE, SHOWING DISCOLORATION OF OLD CRACK

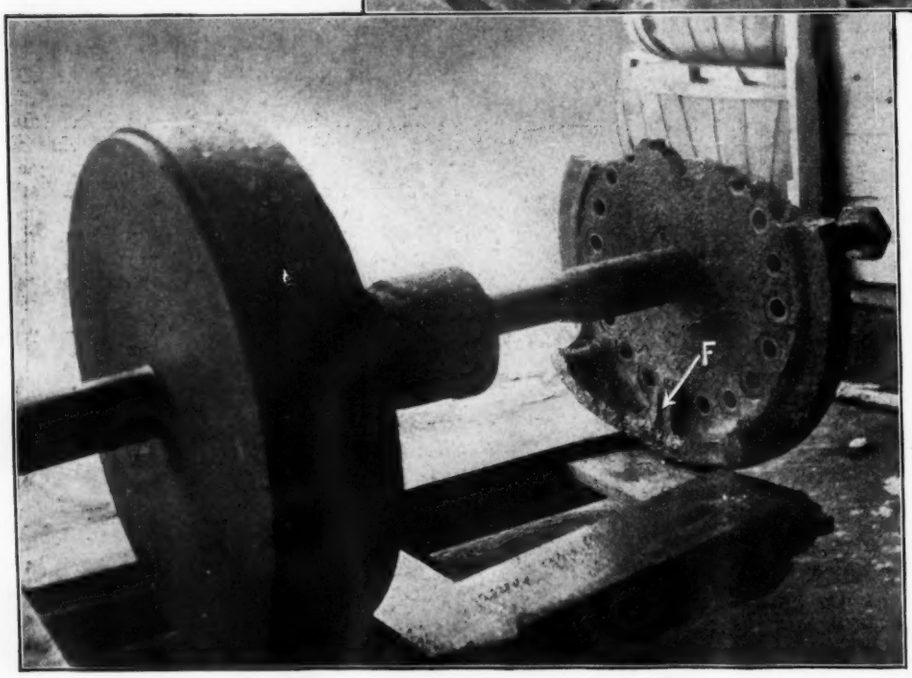


FIG. 7. HIGH-PRESSURE CYLINDER HEAD AND LOW-PRESSURE PISTON

With the crosshead broken and steam admitted to the crank end of the low-pressure cylinder for the return stroke, the conditions that would exist with a broken crosshead, as already shown, would obtain. One point that should be noted is that the faces of the fractures of the distance piece are battered. This could have resulted from but one cause, the total fracture of the casting, both top and bottom, and

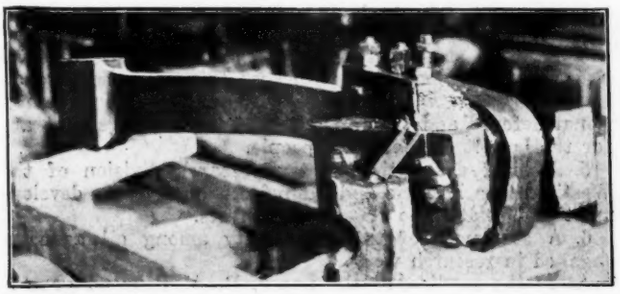


FIG. 9. BENT CRANK ROD AND REMAINS OF THE CROSSHEAD

then the hammering of the broken edges together. This might easily have occurred before the high-pressure cylinder moved away from the low-pressure cylinder sufficiently for the piston to strike the crank-end head.

That the high-pressure crank-end cylinder head was not subjected to such a severe blow as the low-pressure head is evidenced by the fact that it was fractured at but one point, a piece of the flange being broken out at the top, Fig. 7, the point *F* showing the rib with the old crack. A study of Fig. 4 will show the direction of forces that were exerted to result in the various conditions that obtained. Taken as a whole, the case presents an interesting problem.

Although the factory, which manufactures the various apparatus used in the production of honey, is at present forced to operate at greatly reduced output, steps have been taken to obtain power from outside sources until the steam plant is put into operation again at its full capacity.

General Meeting of the American Electrochemical Society

The thirty-second general meeting of the American Electrochemical Society was held at the William Penn Hotel, Pittsburgh, Penn., Oct. 3-6, 1917. Wednesday, the first day of the meeting, was devoted to registration at headquarters and social functions at Oakmont Country Club. The first technical session, Thursday morning, was opened by an address of welcome from Dr. John A. Brashear, who told of many of the epoch-making achievements of the great men who had labored in and about Pittsburgh. Past President L. Addicks, now a member of the Naval Consulting Board, Washington, D. C., gave an outline of some of the work being accomplished by this board in reference to combating the submarine, after which the meeting was devoted to a presentation and discussion of papers, President Colin G. Fink occupying the chair.

Thursday afternoon the members and guests visited various industrial plants and technical colleges situated in or near Pittsburgh. At the evening session Alexander Dow, president of the Detroit Edison Co., gave an address, "Production of Electricity by Steam Power," in which he outlined the design of a power plant for making and utilizing steam efficiently for the generation of electricity, based on, as Mr. Dow put it, "Man-size experiments in which were determined the upper and lower limits." An abstract of Mr. Dow's paper will be published in a later issue of *Power*.

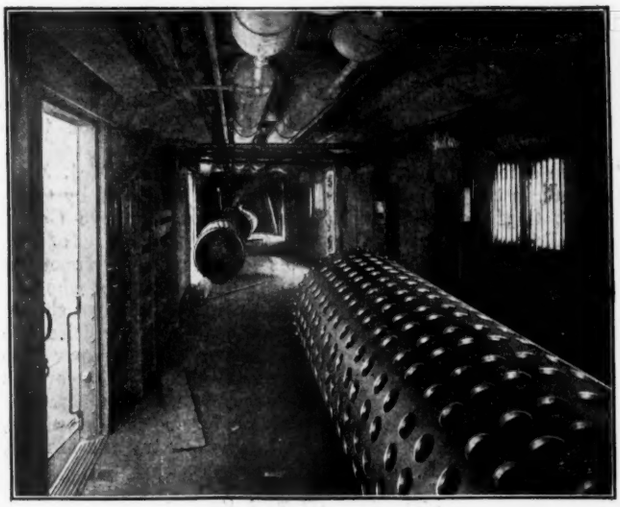
The last technical session was held Friday morning, President Fink in the chair. In the afternoon the members and guests visited a number of the industrial plants in Pittsburgh. An informal dinner was held at the William Penn Hotel in the evening. Saturday was devoted to an all-day excursion on a special train through the most interesting manufacturing centers of Pittsburgh, visiting the plants of the Westinghouse Electric and Manufacturing Co., the National Tube Co., Duquesne Works of the Carnegie Steel Co. and the American Window Glass Co.

The convention was one of the most successful ever held by the society, about 325 members and guests registering. At the technical sessions 29 papers were presented and discussed. Thirteen different excursions were taken, during which 16 industries and technical colleges were visited. The papers presented that are of general interest to *Power* readers are: "Shawinigan and Its Electrochemical Industries," by H. E. Randall; "The Substation Problem of the Electrochemical Plant," by J. L. McK. Yardley; and "Synthetic Gasoline by Electrochemical Means," by L. B. Cherry. Abstracts of these papers will appear in later issues of *Power*.

Boiler by Express

Probably one of the biggest express shipments ever received in Indianapolis arrived recently from Philadelphia for the Merchants Heat and Light Co. in the shape of a 1600-hp. boiler weighing 18 tons.

In line with the progress of this company, the officials knowing that the reserve capacity of their plants would be largely sold by this fall, placed an order for this boiler as early as Mar. 1 of this year for delivery Aug. 1. In the meantime war was declared between this country and Germany, and the Government exercised its right to requisition all supplies and machinery necessary to carry on the war. This interfered seriously with the delivery of this boiler, and it was only after superhuman efforts on the part of the company and due entirely to the plants in this city making



18-TON BOILER IN PALACE HORSE CAR

Government supplies which purchase their power from the Merchants company that the boiler was finally released.

Having secured the boiler, the problem of transportation had to be faced. No car could be secured and no satisfaction obtained from the railroads as to when the boiler could be laid down in Indianapolis. Finally the matter was put up to the express company, which undertook to handle the job, but it was unable to secure a suitable car. At last a palace horse car was found and was set on a siding at 3 p.m. Saturday, Sept. 22, in Morristown. The boiler was loaded by 7 p.m. Saturday and arrived at Indianapolis early Monday morning.

C. J. Cooper, superintendent of heating for the company, who handled the closing details, is of the opinion that this is the first instance in history where a boiler was ever shipped in an electric-lighted, steam-heated Pullman. The express bill was well over a thousand dollars, showing to what an extent the modern public utility will go to protect the service of its patrons.

Philadelphia A. I. E. E. Meeting

Two hundred and seventy-seven members and guests attended the three hundred and thirty-third meeting of the American Institute of Electrical Engineers, held in Philadelphia, Monday afternoon and evening, Oct. 8, 1917. The interest and enthusiasm displayed was characteristic of the meetings held in that city in previous years. The general subject considered was industrial-research work, and the way this was discussed by college professors and practical engineers gave a clear indication that America has awakened to a realization of the important part the research laboratory plays in modern industry.

The afternoon session was called to order by Nathan Hayward, chairman of the Philadelphia section. B. A. Behrend in a brief address called attention to the effects of the war in promoting research in this country and pointed out that as a result of this vast amount of investigation America will be one of the world leaders in the reconstruction period after the war. Vice President L. T. Robinson was then introduced and occupied the chair at the afternoon session. Two papers were presented. The first, "Industrial Research and the Colleges," by Dr. A. E. Kennelly, gave an outline of what the author thought was the proper relationship that should exist in the industrial-research field among the pure-science colleges, the technical schools and the industries themselves. Four ways in which technical colleges can assist in industrial research were given and discussed:

1. Training industrial-research investigators to go out into the industries.

2. The taking up of specific industrial-research problems by particular members of the laboratory staffs, under individual private agreement with industrial concerns, the work being carried on in the college laboratories.

3. The same as in (2), but with the work carried on in the shops of the industrial concerns instead of in the college laboratories.

4. By the industries formulating their problems directly to the college as a corporation and entering into an agreement for the maintenance of research work, in the college laboratories or elsewhere, toward the solution of those problems.

The second paper, "Industrial Research," by Maj. J. B. Jewett, in the absence of the author was presented by Capt. C. B. Craft, of the United States Signal Reserve Corps. It called attention to the fact that "the welfare of the universities and technical schools in their proper functions should be a matter of the greatest concern to all who are engaged or interested in industrial research, and we should be continually on the alert to see that their facilities are ample and functioning to full efficiency." The paper also outlined the method by which industrial research work is carried on by the Bell Telephone system. This research work has expanded until now there are some 600 scientists, coming from over 70 universities in this country and abroad, in the employ of the company.

Discussion of the Papers

After the reading of the papers a lively discussion was entered into by both the college professors and the practical engineers. Although there was considerable difference of opinion as to how far the colleges should go in attempting to carry on research work to prepare students to enter the research laboratories of the various industries, the importance of the work was unanimously conceded.

An informal dinner, which 204 members and guests attended, was served at the Bellevue-Stratford at 6 p m. Nathan Hayward, acting as toastmaster, introduced B. A. Behrend, who complimented the Philadelphia section on the success of its meetings. W. L. R. Emmett, member of the Naval Consulting Board, told how and through what channels the engineer could best coöperate with the Government in the most important single industry in the country, the successful prosecution of the war. One of the most significant features is, when submitting ideas to the various departments in Washington, to accompany them with plans worked out in every detail so that it can be readily seen what they are all about.

At the evening technical session Vice President L. T. Robinson occupied the chair. One paper was presented at this session, "Industrial Research and Its Relation to University and Governmental Research," by C. E. Skinner. This paper may be divided into six sections, as follows:

1. Introduction, emphasizing the great activity in all branches of research at the present time.

2. A division of research activities into three principal classes—university, governmental and industrial.

3. A statement that the principal function of university research should be to train research men and some suggestions as to the type of training required.

4. A brief statement of the function of governmental research, which has to do with such things as the development and conservation of our national resources, the national defense and the promotion of those things that are for the benefit of the whole people.

5. A brief description of the research division of the Westinghouse Electric and Manufacturing Co., its development and relation to other departments.

6. A statement of the desirability among all agencies engaged in research work.

After the reading of the paper, B. A. Behrend gave a short talk on the development of the turbo-alternator and some of the methods that are employed to determine how the various parts of the machine are stressed. The speaker complained of the lack of theoretical knowledge, even today, on many points involved in the design of this equipment, and pointed out that a vast amount of research work by the technical colleges could be carried out along this line.

The meeting was then thrown open to a discussion of Mr. Skinner's paper and Mr. Behrend's remarks, in which Prof. V. Karapetoff and Prof. Alexander Gray, of Cornell University; Dr. Harold Pender, University of Pennsylvania; William McClellan, dean, Wharton School of Science; Prof. Comfort A. Adams, Harvard University; Prof. C. E. Scott, Yale University; P. G. Agnew, Bureau of Standards, Washington, D. C.; L. W. Chubb, research laboratory, Westinghouse Electric and Manufacturing Co.; W. L. R. Emmett, member Naval Consulting Board; Oberlin Smith, president, Ferracute Machine Co.; and others took part.

In summing up, Mr. Skinner pointed out that 100 research men are needed for every genius and that we are going to require an ever-increasing number of research men, therefore every effort must be put forward to develop these men.

The meeting was closed after a motion put by Prof. C. E. Scott that the board of directors of the American Institute of Electrical Engineers consider the appointment of a standing committee on research.

Loss in Heat Value of Coal in Storage

A report on the deterioration in the heating value of coal during storage, covering a five-year period, has been issued by the Bureau of Mines, Department of the Interior, as Bulletin 136, Horace C. Porter and F. K. Ovitz being authors.

The tests show that the deterioration of coal during storage has commonly been overestimated. Except for the sub-bituminous Wyoming coal, no loss was observed in outdoor weathering greater than 1.2 per cent. in the first year, or 2.1 per cent. in two years. The loss in heating value is given for New River and Pittsburgh coals during five years' storage in the open air and under water, for Pocahontas during two years' storage in the air, and for Sheridan, Wyo., coal during 2¾ years' storage in the air.

The tests with New River and Pittsburgh coal were made to determine the advantage to be gained by storing coal under water, particularly under salt water. The results show that storage of New River coal under water effectively prevents deterioration of calorific value and that storage in the air under severe conditions causes only small deterioration—about 1 per cent. in one year's exposure and about 2 per cent. in two years. After two years the loss is continuous but slow, reaching 2.5 to 3 per cent. in five years. The deterioration of Pittsburgh coal during one year's open-air storage was practically negligible. During the second, third, fourth and fifth years the deterioration proceeded very slowly and did not reach an amount greater than 1.1 per cent. in five years. The submerged portions suffered no loss measurable by the degree of accuracy of the methods used.

The tests of Pocahontas coal, a semibituminous type, were undertaken chiefly to determine the effect of tropical conditions in Panama. They were made on an outdoor pile of 100 tons of run-of-mine coal. During two years' outdoor exposure this coal deteriorated less than 1 per cent. in heating value.

The Sheridan, Wyo., sub-bituminous coal, known also as "black lignite," is commonly supposed to deteriorate rapidly in storage, especially by "slacking" or crumbling of the lumps. Under the conditions of the tests this coal lost 3 to 5.5 per cent. of its heat value in 2¾ years' storage, the greater part of this loss being in the first nine months. In general, the lumps became badly cracked, but retained their form sufficiently to permit ready access of air. However, they were weakened so that they broke up badly on handling. By the use of bins with air-tight bottoms and sides and a protecting layer of fine slack on the surface, the deterioration of Sheridan coal in heat value can probably be kept below 3 per cent. in one year and the physical deterioration can also be largely prevented in the under portions of the pile.

The results show that the amount of deterioration of coal during storage has commonly been overestimated. With coal such as New River and Pittsburgh the expense of underwater storage equipment is not justified except as a preventive of fires from spontaneous combustion.

Detailed results and a full account of the tests and analytical data are given in the bulletin, which may be obtained free of charge by addressing the Director of the Bureau of Mines, Washington, D. C.

Personals

F. L. Converse, electrical engineer for the Coatesville (Penn.) branch of the Midvale Steel Works, has resigned to go with the Tacony Ordnance Co., Philadelphia.

C. F. Goodrich, assistant manager of the Buffalo Forge Co.'s Boston office, has left for active duty as first lieutenant in the Ordnance Department, and is stationed at the Watervliet Arsenal.

Don R. Marsh, production manager with the Buffalo Forge Co., has given up his work to assume similar duties at Washington in the production of ammunition. He will receive a captain's commission.

Charles C. Cheyney, manager of the Chicago office and store of the Buffalo Forge Co., has a commission in the Naval Aëronautic Corps and is beach engineer at Pensacola, Fla., in charge of airplane engines.

H. F. Bardwell, who is well known to the buyers of tool steel in the East, has been appointed New York district manager for the Vanadium-Alloys Steel Co., of Pittsburgh and Latrobe, Penn., with offices at 30 Church St., New York City.

Engineering Affairs

The Ohio Society of Mechanical, Electrical and Steam Engineers will hold a meeting in Columbus, Ohio, Nov. 15.

Elmer E. Chambers Council No. 5 of the Universal Craftsmen Council of Engineers, held its second annual reception and dance at Palm Garden, New York City, on Tuesday, Oct. 16. An enjoyable entertainment was followed by dancing. A pleasing artistic feature of the evening was the electric-light effect, with waving American flags displayed from the stage during the grand march, while the attendants sang the "Star Spangled Banner." The officers of the council are: Edward Northrup, past worthy chief; Leo E. Kenney, worthy chief; R. W. Wersnig, assistant chief; F. F. Fleniken, recording secretary; R. Temler, financial secretary; George F. Quelet, treasurer; D. Doddridge, warden; Frederick Drews, guard; C. Ten Eyck, chaplain; Alfred S. Stevens, organist; Frank Martin, of Jenkins Bros., was the floor director.

The Electrical Exposition and Motor Show of 1917 was held in the Grand Central Palace, New York, Oct. 10-20. This year, as in the past, the electric light played an important rôle; how to have more light and better light in the home and industries was shown in many ways. Along with the electric light and almost equally prominent was a multiplicity of electrical conveniences for the home, so varied in application as to give the impression that this is the age of the electrical home. The array of industrial equipment, although not bedecked in the splendor of the domestic variety, also occupied a seat of honor. In this respect one of the most conspicuous features was the dearth of new devices compared with what was shown in previous years, which is evidence that the electrical manufacturers have not, under the stress of industrial demands for standard equipment, been giving serious attention to developing new devices. Intermingled with those accessories that occupy such an important part in our peaceful pursuits were others that play a vital part in the prosecution of war. That this country is at war was in evidence on every side, not only from the numerous exhibits, but also from the interest displayed in them by the public. The War Department, Navy Department, Red Cross Society, United States Food Administration and New York City Food Aid Committee all had exhibits. The entire third floor was given over to the Red Cross exhibit, which was the largest single display. One of the unique features of the Signal Corps equipment was a portable generator for wireless work, which in service is driven by two men turning cranks. The outfit is so arranged that it may be transported from place to place on a mule's back. Other Government exhibits were those of the Department of Commerce, Light House Service, Weather Bureau, Forest Service, the Census Bureau, and Bureau of Public Roads. New York State displayed models showing the working of parts of the State Barge Canal. New York City showed models illustrating various features of the new acqueduct system.

Trade Catalogs

Steam Traps. Farnsworth Co., Conshohocken, Penn. Circular. Illustrated.

Steam Traps. Armstrong Machine Works, Three Rivers, Mich. Catalog. Pp. 24; 6 x 9 in.; illustrated.

Link-Belt Rope Tramway System, Watson Type. Link-Belt Co., Chicago, Ill. Book No. 343. Pp. 8; 6 x 9 in.; illustrated.

Nonpareil Insulating Brick for Boiler Settings. Armstrong Cork and Insulation Co., Pittsburgh, Penn. Folder. Illustrated.

Fisher Steam Trap, Type No. 33. The Fisher Governor Co., Marshalltown, Iowa. Bulletin No. 1101. Pp. 4; 6 x 9 in.; illustrated.

The Model Automatic Smokeless Furnace. The American Foundry and Casting Co., Dayton, Ohio. Catalog. Pp. 48; 6 x 9 in.; illustrated.

Pot Valve Pressure Pumps. Worthington Pump and Machinery Corp., 115 Broadway, New York. Bulletin W-500. Pp. 48; 6 x 9 in.; illustrated.

Angle-Compound Power-Driven Air Compressors. Sullivan Machinery Co., 122 South Michigan Ave., Chicago, Ill. Bulletin No. 75-C. Pp. 32; 6 x 9 in.; illustrated.

Tandem Compound Corliss Air Compressors, Class WC. Sullivan Machinery Co., 122 South Michigan Ave., Chicago, Ill. Bulletin No. 75-F. Pp. 32; 6 x 9 in.; illustrated.

Oil Filters, Exhaust Heads, Ventilators. Burt Manufacturing Co., Akron, Ohio. Catalog. Pp. 128; 6 x 9 in.; illustrated. This is a very attractive catalog describing the different types of oil filters and the use of the ventilators and exhaust heads made by this company.

"Let 85% Magnesia Defend Your Steam" is the title of a pamphlet issued by the Magnesia Association of America, 702 Bulletin Building, Philadelphia, Penn., which covers the subject of heat insulation and the part which 85% magnesia plays in different insulation systems.

Business Items

Paige & Jones Chemical Co. announces the removal of its general offices from 51 East 42nd St. to 15 East 40th St., New York City.

The Electric Machinery Co. has established a branch office in New York City, with district offices in Boston, Philadelphia and Buffalo to take care of growing business in the Eastern States.

The Electric Machinery Co., of Minneapolis, Minn., has started work on a new factory to adjoin the present main site, which will make the plant more than twice its present size. It will be completed and in full operation about Jan. 1, 1918.

Griggs & Myers, consulting engineers, of New York City, have been retained by the Wright Wire Co., of Worcester and Palmer, Mass., to design and supervise the installation of its modern 12,000-kw. power station, to be used in connection with the present works of the company at Palmer.

Worthington Pump and Machinery Corp. announces the opening of a new branch sales office at American Trust and Savings Bank Building, Birmingham, Ala., to take care of a portion of the large territory hitherto controlled by the Atlanta office. Edward Stauverman, formerly with the Atlanta office, will be in charge of the new branch as manager.

New Publications

THE WEST INDIES AS AN EXPORT FIELD

A handbook of nearly 400 pages on American trade in the West Indies has been issued by the Bureau of Foreign and Domestic Commerce. Figures given show the importance of the field, for more American goods were sold to those islands, including Porto Rico, in 1916 than to the entire continent of South America. They took $191,195,791 worth, whereas the sum total of American shipments to South America was $177,628,611. Cuba alone purchased more merchandise than Argentina, Brazil, Bolivia, Ecuador, Uruguay and Paraguay combined. China, with its 400,000,000 population, purchased only one-seventh as much of American goods as the West Indies. As a matter of fact, the West Indies took considerably more than two-thirds as much of our goods as the whole continent of Asia and all the islands of the East Indies, more than 2½ times as much as Australia, New Zealand, and the rest of British Oceania, 4½ times as much as all Africa. In short, the islands constitute one of the very best markets for the products of American factories, fields and mines.

The report was written by Special Agent Garrard Harris. Its treatment of each country and colony is comprehensive, although the commercial point of view is never lost sight of. In the section devoted to Cuba, for instance, there is a brief description of the language, currency, weights and measures, postage, and the telephone, telegraph, and wireless systems. Then comes a short historical sketch, following which there are chapters on location and area, physical characteristics, sanitation and health, and population and distribution. Next in order is a description of the different provinces, with a sketch of the resources, industries, transportation facilities, etc., of each. The other chapters relate to such subjects as the recent commercial progress of the country, agricultural products, fibers, stock raising, forest resources, manufacturing industries, mineral resources, mineral waters and baths, labor and wages, rents and living expenses, government and education, courts and civil laws, trade marks and patents, lands and titles, taxation, banks and banking, foreign trade, customs tariff, commercial travelers and their samples, and concluding the section there is a chapter on the outlook for the future. To Cuba alone 69 pages are devoted.

Copies of "The West Indies as an Export Field," Special Agents' Series No. 141, may be obtained for the nominal price of 50c. each from the district offices of the Bureau of Foreign and Domestic Commerce, or the Superintendent of Documents, Government Printing Office, Washington, D. C. Coöperative offices have copies to sell to those who apply in person.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Oct. 21, 1917	One Year Ago	Oct. 21, 1917	One Year Ago
Buckwheat ..	$4.98—5.20	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.40—4.65	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	3.90—4.15	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Oct. 21, 1917	One Year Ago	Oct. 21, 1917	One Year Ago
Clearfields ...	$2.42—3.47	$3.00	.....	$4.25—5.00
Cambrias and Somersets...	2.42—3.47	3.10—3.85	.....	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago; on cars Boston price is $8.50—8.75.
*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Oct. 21, 1917	One Year Ago	Oct. 21, 1917	One Year Ago
Buckwheat ..	$3.95—4.65	$2.75	$5.10—5.30	$2.75—3.00
Rice	3.40—3.60	2.20	3.80—4.10	2.10—2.30
Barley	2.90—3.15	1.95	3.00—3.30	1.90—1.95

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate).....	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Oct. 21, 1917	One Year Ago	Oct. 21, 1917	One Year Ago
Buckwheat ...	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	1.90
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	1.65

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Oct. 21, 1917	One Year Ago
Slack	$3.00—3.25	$4.00—4.50
Mine-run	3.00—3.25	3.25—3.75
¾-in.	3.50—3.75	3.35—3.85

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump ..	$2.20	$2.20	$2.40	$2.20	$2.20
Lump	2.20	2.20	2.40	2.20	2.20
Egg	2.20	2.20	2.40	2.20	2.20
Nut	2.20	2.20	....	2.20	2.20
No. 1 nut....	2.20	2.20	....	2.20	2.20
No. 2 nut....	2.20	2.20	....	2.20	2.20
No. 3 nut....	2.20	2.20	....	....	....
No. 1 washed.	2.20	2.20	....	....	....
No. 2 washed.	2.20	2.20	....	....	....
Mine-run	1.95	1.95	2.15	1.95	1.95
Screenings	1.70	1.70	1.90	1.75	1.70

Hocking lump, $2.60; splint lump, $2.40.

Northern Illinois thin vein—Prepared sizes, $2.65; mine-run, $2.40; screenings, $2.15.

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Oct. 21, 1917	One Year Ago	Oct. 21, 1917	One Year Ago	Oct. 21, 1917	One Year Ago
6-in. lump ..	$2.35	$2.25	$2.35*	$2.00	$2.35	$1.85
2-in. lump ..	2.35	2.00	2.35*	2.00	2.35	1.85
Steam egg...	2.35	2.15	2.35*	2.00	2.35	1.75
Mine-run ...	2.10	1.35	2.10*	1.50	2.10	1.30
No. 1 nut...	2.35	2.00	2.35*	2.00	2.35	1.75
2 in. screen..	1.85	1.00	1.85*	1.00	1.85	.95
No. 5 washed	1.85	.90	1.85*	.90	1.85	.90

*Strike.
Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona....	2.15	2.40	1.90
Black Creek, Cahaba ...	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

B. C., Trail—The Silver Standard Mine plans to install a new power plant consisting of a gasoline engine, dynamo compressor, boiler plant and shop equipment. A concentrator may also be erected.

Calif., Barstow—The Southern Sierras Power Co., 611-12 Symes Bldg., Denver, Colo., plans to build a power line from here to Victorville. Estimated cost, $115,000. C. O. Poole, Ch. Engr.

Del., Wilmington—The Diamond State Telephone Co., 6th and Shipley Sts., has been granted a permit by the Street and Sewer Dept. for the installation of underground conduits in eight streets and avenues.

Ind., Monticello—City Council plans to build and operate an electric-light and power plant.

Iowa, Cedar Rapids—The Iowa Railway and Light Co., Cedar Rapids, has been granted a franchise by the Board of State Railroad Commissioners for the construction and operation of electric transmission lines in Muscatine County. D. Wardle, Ch. Engr.

Iowa, Dunbar—City voted in favor of a $7000 bond issue for the installation of an electric-lighting system.

Ky., Murray—City issued $20,000 bonds for the installation of an electric-lighting and water-works system and power plant.

Mass., Boston—The Crosby Steam Gauge and Valve Co., 38 Central St., has had plans prepared for the erection of a new 1-story, 25 x 40-ft. power house addition to its plant.

Mass., Boston—The Edison Electric Illuminating Co., 44-48 Chauncy St., plans to erect a brick transformer station.

Mich., Grand Rapids—City plans to install a new lighting system, including additional lights and machinery for which a sum of $30,000 is available. J. C. Parker, of the State University, has completed a survey.

Mo., Oran—City plans an election to vote on a bond issue for the erection of a lighting plant.

Mont., Poplar—M. A. Erickson, of La Moure, plans to install an electric-lighting plant here to be driven by a 100-hp. steam engine.

N. J., Newark—The Titan Co., 8 Lister Ave., plans to build a 1-story, 50 x 70-ft. steel boiler room. Estimated cost, $4100.

N. J., Perth Amboy—The American Smelting and Refining Co., Maurer St., plans to build a new 1-story, 60 x 70-ft. power plant at its Maurer works.

N. J., Trenton—The Delion Tire and Rubber Co., Whitehead Rd., has had plans prepared by J. O. Hunt, Arch., 114 North Montgomery St., for a new 2-story, 30 x 45-ft. power house addition to its plant.

N. J., West Orange—T. A. Edison, Inc., Lakeside Ave., plans to build a new 1-story, 100 x 100-ft. reinforced-concrete power plant here.

N. Y., Fulton—The Volney Paper Co., North 1st St., has had plans prepared by Sackett & Park, Arch., 34 Syracuse Saving Bank Bldg., Syracuse, for the erection of a 1-story, 35 x 50-ft. power house.

N. D., Maddock—City at recent election voted favorably on the proposal to erect and operate an electric-lighting plant.

Okla., Eufaula—City has had plans prepared by J. L. Lowe, Engr., for a power plant at the river, including a brick boiler house, pumping room, etc.

Okla., Wapanucka—City at recent election voted in favor of a $6000 bond issue for electrical improvements. W. J. Terry, Pres. Bd.

Ont., Seaforth—The R. Bell Engine and Thresher Co., Ltd., is in the market for an electric motor 35 to 50 hp., 25 cycle, 3-phase, 220 volts, 750 revolutions.

Ore., Gold Hill—The City Council plans to install and operate a power plant and water-works system. Estimated cost, $25,000.

Penn., Grove City—The Grove City Creamery Co., Grove City, is having plans prepared by K. E. Parks, Engr., 13th and B Sts., S. W., Washington, D. C., for the erection of a new power-plant addition to its works.

Penn., Hazelton—The Harwood Electric Co., 814 Markel Bank Bldg., will soon award the contract for the erection of an electric transmission line to Conyngham. J. B. Macfarlane, Lansford, Engr.

Penn., Pittsburgh—O. Werner & Sons Co., Bryant and St. Clair Sts., plans to build a 1-story brick boiler house. Estimated cost, $6322.

Penn., Shamokin—The City Council has had plans prepared for a new street-lighting system.

Tenn., Alamo—City voted in favor of a $10,000 bond issue for the installation of an electric-lighting plant.

Tenn., Portland—The Portland Electric Co., recently incorporated with a capital stock of $10,000, plans to build an electric-lighting plant here. The incorporators are R. D. Moore and W. C. Austin, both of Portland.

Wis., Milwaukee—The International Harvester Co., 606 South Michigan Ave., plans a boiler-house addition to its plant at 784 Park St. Estimated cost, $15,000.